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Chaetognatha of the Caribbean Sea and Adjacent Areas

Harding B. Michel

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Chaetognatha of the Caribbean Sea and Adjacent Areas

HARDING B. MICHEL[1]

ABSTRACT

This illustrated manual is a guide to the distribution and identification of the 6 genera and 28 species of benthic and planktonic Chaetognatha known to occur in the Caribbean Sea, the Gulf of Mexico, the Florida Straits, and the southwestern North Atlantic Ocean. As background, previous studies of chaetognaths in these areas are reviewed, gross morphology of the different forms is described, and instructions on methods of preserving and handling specimens preparatory to identification are provided. The key to genera and species is preceeded by a discussion of chaetognath taxonomy. A description of each species, consisting of an abbreviated synonymy, a summary of taxonomically important morphological features, and horizontal and vertical distribution follows the key. The occurrence of species in relation to water masses in the Caribbean and adjacent areas is noted.

INTRODUCTION

After Conant (1895, 1896) and Ritter-Záhony (1910) pioneered in describing species from the tropical western Atlantic, almost nothing was written about the chaetognaths in these areas until Pierce (1951) published his work on species collected off the west coast of Florida. Subsequently, Tokioka (1955) dealt with taxonomic problems arising from Pierce's studies, and Suárez-Caabro (1955, 1959) published his works on the distribution of species occurring in Cuban waters. Colman (1959) added records of occurrence in his report on the *Rosaura* collections, which included vertical tows from the upper 1,000 m in the Caribbean Sea. In 1960, Owre summarized previous work in a study of the distribution of 16 species occurring in the Florida Straits off Miami, and the deduced reproductive periods of the more numerous forms. Legaré and Zoppi (1961) reported on the abundance and distribution of 10 species from Venezuelan waters. Alvariño (1969) tabulated the Atlantic records of 31 species and illustrated them comprehensively.

Owre and Foyo (1971, 1972) reviewed previous investigations of Caribbean zooplankton and, in the latter paper, discussed the results of the first cruise in a series, sponsored by the University of Miami, which was begun in January 1966 and was completed in November 1969. The purpose of this series was to examine the distribution of major groups of zooplankton in relation to water masses in the Caribbean and adjacent areas. After the first cruise, improved sampling procedures (Owre and Low 1969) were consistently used on the nine subsequent cruises, the results of which were presented by H. B. Michel (formerly Owre), M. Foyo, and D. A. Haagensen (1976). The locations of stations at which horizontal plankton tows were made at several depths between surface and bottom are shown in Figure 1.

Investigations by Hensley (1977) on zooplankton composition in the upper 100 m off northern Cuba, and by McLelland (1978) on chaetognaths in the northeastern Gulf of Mexico have added information on occurrence and distribution in these areas.

The occurrence of the benthic genus *Spadella* in the western North Atlantic was discussed by Owre (1963), who described two new species and wrote a key to the species then known. In 1970, Alvariño described a new species from Puerto Rico. Further information on characteristics and distribution appeared in a report on extensive Bahamian collections (Owre 1972b).

The physiological ecology of chaetognaths has been investigated through laboratory studies on *Sagitta hispida*, a common species in neritic Florida, Gulf and Caribbean waters, the oceanic *Sagitta enflata*, and the benthic *Spadella cephaloptera* (Reeve 1964a, 1966, 1970a, b; Reeve and Cosper 1975; Reeve and Lester 1974; Reeve et al. 1970; Reeve and Walter 1972a, b; Feigenbaum 1977, 1978; and Feigenbaum and Reeve 1977).

The occurrence and distribution of chaetognaths in the tropical western Atlantic are thus generally well known, but no single work treating both benthic and planktonic species and serving as a guide to identification and distribution exists. In view of the growing interest of the many Caribbean countries, as well as the United States, in marine ecosystems, comprehensive reference works for use in teaching and research are needed. The Chaetognatha, as primary planktonic predators in the marine food web as well as valuable indicators of water masses, grow in significance as more is learned of their ecology. New data have emerged on the horizontal and vertical distribution and the systematics of the group from surveys in the Caribbean and adjacent areas (Owre and Foyo 1971, 1972; Owre 1973; Michel et al. 1976; Stepien 1980). It is now appropriate to summarize this information, providing an illustrated key to benthic and planktonic species, with an abbreviated diagnosis of each species and information on distribution.

With the exception of a few works of historical interest, the Literature Cited primarily concerns literature pertaining to the chaetognaths of the southwestern North Atlantic, Gulf, and Caribbean areas. Extensive bibliographies are found in the works of Hyman (1959), Ghirardelli (1968), and Alvariño (1969).

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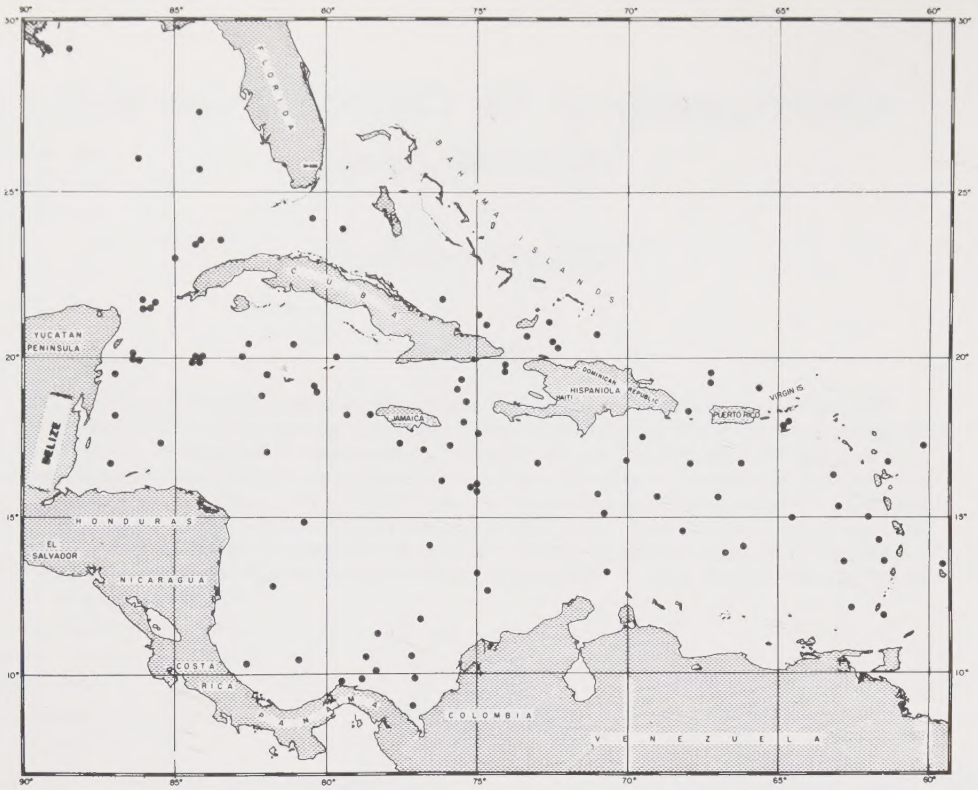

Figure 1.—Locations of stations at which complete series of plankton samples were collected in nets towed horizontally at as many as 13 levels, usually 6 or 7, between the surface and depths near bottom (after Michel et al. 1976).

CLASSIFICATION

Anatomy

The morphology of chaetognaths has been described in several monographs summarized by Hyman (1959) and Ghirardelli (1968). Most of the features of gross morphology currently used in the identification of genera and species are shown in Figure 2.

The elongated body is differentiated into three regions, head, trunk, and tail, sometimes called the caudal segment. Transverse septa partition the head from the trunk and the trunk from the tail. Total length (L) is measured from the tip of the fleshy head at the midline to the tip of the tail, excluding teeth which may protrude anteriorly and the caudal fin posteriorly. As Thompson (1947) pointed out, Ritter-Záhony (1911b) recommended this measurement because of the delicacy of the caudal fin. Unfortunately, some workers have included the fin, and thus not all published measurements are comparable. The length of the tail (T), i.e., from the transverse septum to the tip, excluding the caudal fin, is routinely used as a specific character when expressed as a percentage of the total length: T/L = T%.

One or two pairs of lateral fins, in the latter case called anterior fins and posterior fins, and a caudal fin are always present. These are not muscular structures but thin lateral extensions of the epidermis, stiffened by rays which may support all of the fin or parts of it or, in the case of *Bathybelos typhlops*, be lacking altogether. Ghirardelli (1968) rejected the suggestion that the fin rays are made of collagen; their composition apparently remains unknown. The number of lateral fins, their position on the body, and the shape and sometimes the arrangement or absence of the fin rays are all useful characteristics in well-preserved specimens. The student normally encounters difficulty in seeing the form and extent of the lateral fins and must learn to manipulate the microscope light and the specimens to reveal these features. Robert Bieri[2] recommends staining with aniline blue, which can be prepared as a strong aqueous solution and used drop by drop, according to the amount of fluid containing the specimens. The stain emphasizes the fins. Phase contrast and dark-field microscopy are also effective in showing external structures.

Species of the benthic genus *Spadella* are adapted to adhere to the substrate by glandular areas on the posterior part of the body. In most species, these adhesive structures occur at the tips of digitate extensions from the lateral or caudal fins or from the tail itself (see Figs. 7, 8). In *Spadella cephaloptera*, the glandular areas are located on the ventral side of the tail, and there are no digitate processes (see Fig. 6).

On the head, in an anterior-ventral position, are one or two paired rows of small, elongate teeth, except in the deep-living, little-known genus *Krohnittella*, which has no teeth. If there are two pairs of rows, as in *Sagitta* and *Pterosagitta*, the anterior rows are called the anterior teeth and those posterior, the posterior teeth (Fig. 3). In species of *Spadella*, there usually are no posterior teeth although a few may be present in *S. cephaloptera*. The genera *Eukrohnia* and *Krohnitta* have only a single pair of rows of long teeth (Fig. 4). Several much larger curved, grasping hooks are

[2]R. Bieri, Professor, Environmental Studies Center, Antioch College, Yellow Springs, OH 45387, pers. commun. July 1978.

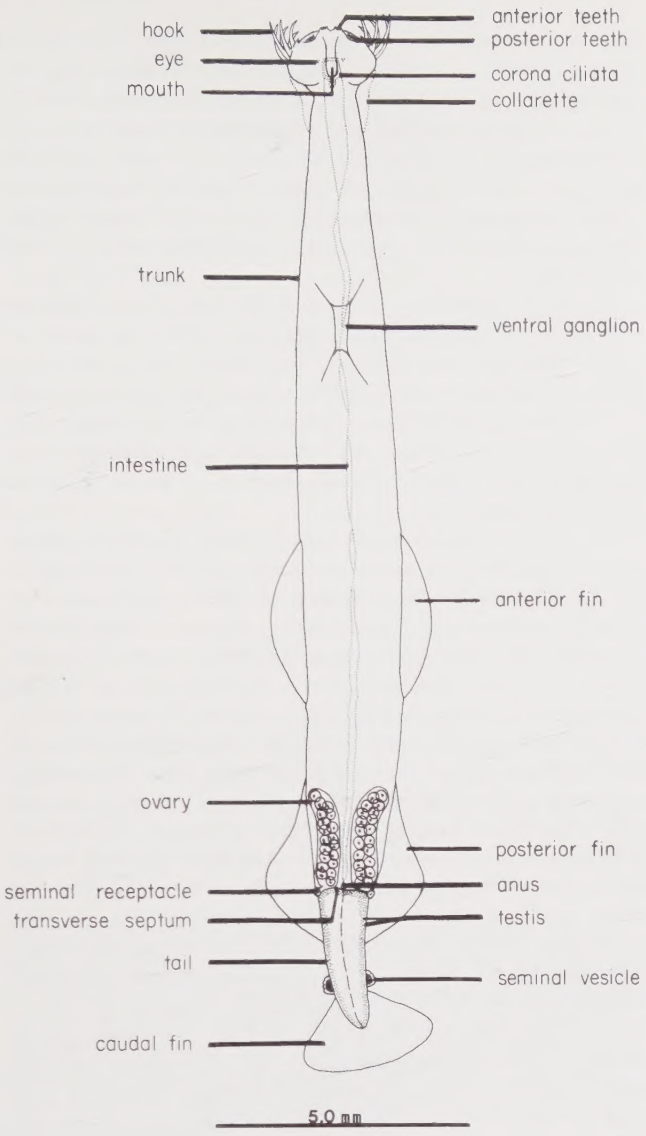

Figure 2.—*Sagitta enflata*, dorsal view: A diagram showing gross anatomy.

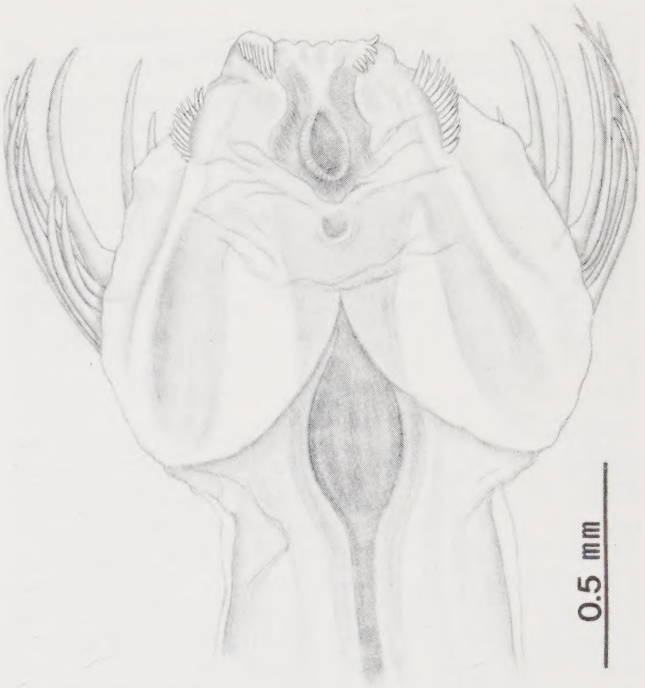

Figure 3.—*Sagitta planctonis*, forma *zetesios*, immature, ventral view of head.

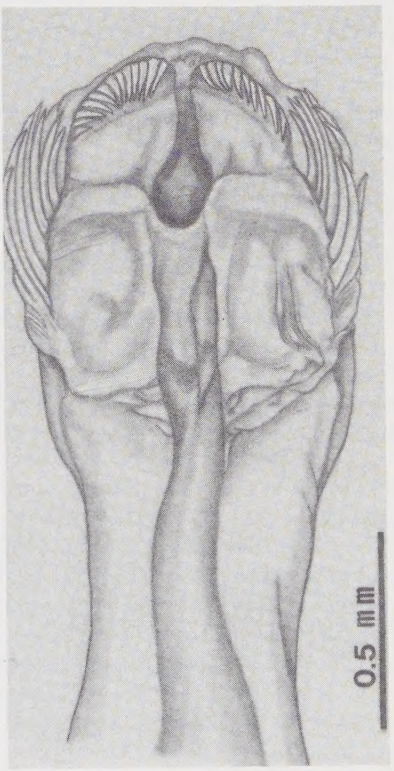

Figure 4.—*Krohnitta subtilis*, ventral view of head.

situated in a row on each side of the head (see Figs. 2, 3, 4). The formation and position of these structures, as well as the number present in an animal of a particular length, all serve as taxonomic characteristics. The total number of teeth of each kind on each side of the head is counted. In identifying a chaetognath, the figures for total length, the percentage the tail occupies (T/L), and the numbers of teeth and hooks can be specified in the following way:

L: 11.8 mm; T% 28
H (hooks on each side): 7-8
Ta (anterior teeth on each side): 9-8
Tp (posterior teeth on each side): 11-11.

In characterizing a species, authors usually have tabulated the range of T% and numbers of teeth and hooks for a particular size range, either as found in one collection or else as a summary of knowledge, e.g., Ritter-Záhony's (1911a) data (Table 1).

Table 1.—Data of 25 *Sagitta bipunctata* from the Atlantic Ocean (from Ritter-Záhony 1911a).

Length (mm)	T%	Hooks	Anterior teeth	Posterior teeth
19	21	10	6	16
15	23	8-9	7-8	14-15
14	24-25	9-10	7-8	13-15
13	23-25	8-10	6-7	12-16
12.5	24-25	8-9	6-8	12-14
12	23-26	9-10	5-7	13-14
11.5	24-26	9-10	5-6	13
11	28	9-10	7	14

The two small eyes on the dorsal surface of the head consist of five cups (cupolae) which are pigmented except in some meso-and bathypelagic species. The size, shape, orientation, and pigmentation of the cups may serve as taxonomic characters (Ghirardelli 1968). I have found them useful in differentiating immature *Sagitta hispida* and *S. helenae*, as did Tokioka (1955), and mature *S. decipiens* (see Fig. 19). Eakin (1968), Eakin and Westfall (1964), and Ducret (1975, 1977) have made extensive studies of the structure and ultrastructure of the chaetognath eye.

When a chaetognath is not seeking food or feeding, the head is streamlined by a fold of the body wall, the hood, which extends over the hooks and teeth. Fortunately, animals usually retract the hood when dying in preservative; if it remains in place, it must be dissected to reveal teeth and hooks.

In some species, the epidermis commencing in the region of the neck consists of large vacuolated cells which form a structure of varying thickness termed the collarette. The collarette may be restricted to the neck (see Fig. 39), reach the anterior fins (see Fig. 35), or extend to or past the transverse septum (Fig. 5). It is sometimes damaged or destroyed during collection.

On the dorsal surface of the head and neck, sometimes extending onto the trunk, is the corona ciliata or ciliary loop. Staining is required in order to see it on preserved specimens of most species. The species of *Spadella* treated here are exceptions. The corona is a delicate epidermal structure which may be abraded during capture. Although Ritter-Záhony (1911a, b) and others have considered its form a good taxonomic character, it can be variable, as Ghirardelli (1968) pointed out in his thorough discussion. Neither its histological structure nor its function has been finally determined by the several workers who have studied it, but they seem to agree that it consists of two concentric rings of cells of ectodermal origin. These are difficult to differentiate in pelagic chaetognaths and supposedly are composed of the same kind of cell. In *Spadella*, however, the inner corona is formed by pyriform glandular cells and the outer by smaller ciliated cells. Some believe that a narrow canal separates these two and that the organ is excretory. Others think that its function is largely sensory. Also, in a long series of observations and experiments summarized in his 1968 work, Ghirardelli showed that, in *Spadella cephaloptera*, the secretions and ciliary action of the corona contribute to the movement of sperm to the seminal receptacles after reciprocal copulation has resulted in the deposit of a spermatophore in the dorsal neck region.

On the ventral surface of the anterior trunk lies a prominent rectangular structure, the ventral ganglion. This is the center for innervation of the trunk and tail. The location of the anterior edge of the fins and the extent of mature ovaries with reference to the ventral ganglion are features which may be used in taxonomy. As the ganglion is epidermal and superficial, rough handling may dislodge it, but it usually remains attached by one of the nerves which issue from it.

The presence of minute projections from the body surface, arranged in orderly rows, has been recognized for more than a century. The structure and function of these ciliated epidermal sensory receptors have recently been examined by Feigenbaum and Reeve (1977) and Feigenbaum (1978), who refer to the more numerous kinds as "hair fans," and by Bone and Pulsford (1978), who call them "ciliary fences." Using a scanning electron microscope to view *Spadella cephaloptera*, Bone and Pulsford found two kinds of sensory structures in addition to the ciliary fences, stout single cilia on head and tail, and, on the head, presumed sensory cells with ciliated invaginations of the cell surface. They further observed groups of pointed bristles scattered over the body surface and noted that they are distinct from the sensory cilia. The hair fans or ciliary fences, which have also been studied in *Spadella schizoptera*, several species of *Sagitta*, and *Pterosagitta draco*, enable the organism to receive near-field low frequency vibrations (Feigenbaum and Reeve 1977; Bone and Pulsford 1978).

The general aspect of the body is used to separate two groups within the genus *Sagitta*. Most species are relatively slender with strong longitudinal musculature so that the body tends to be rigid when preserved, e.g., *S. bipunctata*, *S. hispida*, and *S. serratodentata* (see Figs. 18, 26, 37). In others, the body is broader, more inflated and less heavily muscled in comparison, and it may collapse during capture so that the preserved animal has a flaccid appearance. Examples of the latter form are *S. enflata*, *S. hexaptera*, and *S. lyra* (see Figs. 20, 25, 27).

Within the body, the three coelomic cavities are located in the head, the trunk, and the tail. Coelomic space in the head is virtually obliterated by muscles, nervous tissue, and anterior portions of the digestive system. It is separated from the trunk coelom by a transverse septum, and another septum partitions the trunk from

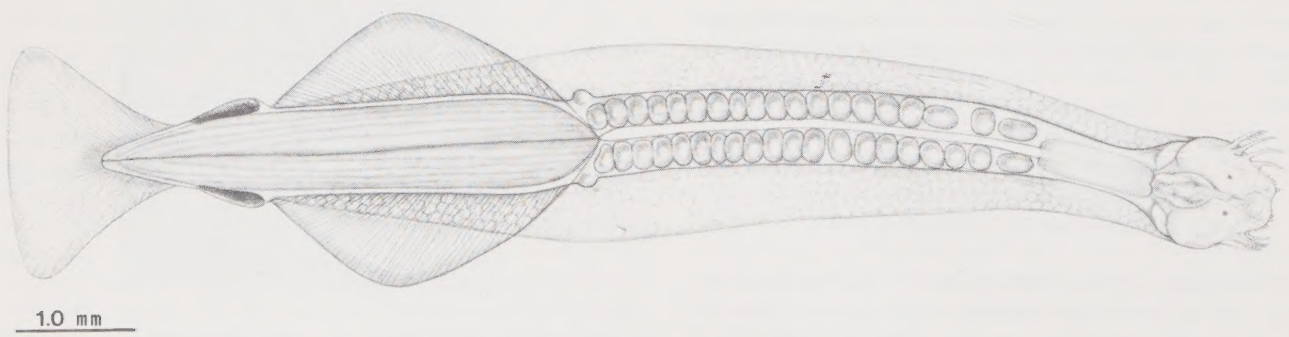

Figure 5.—*Pterosagitta draco*, dorsal view.

the tail coelom (see Fig. 2). There are commodious coelomic spaces in trunk and tail. In the trunk, the space is divided longitudinally into two compartments by the median dorsal and ventral mesenteries which support the intestine. The tail coelom is also divided by a median, longitudinal, dorsoventral mesentery, represented in Figure 2 by a dashed line. In her summary, Hyman (1959) stated that "A true coelom is formed by the enterocoelous method during the embryonic stages of chaetognaths, but this is suppressed in the larva. . . . At any rate the definitive space between body wall and intestine and in the tail is not lined by a peritoneal membrane." This is a prevalent opinion. However, routine thin-sections I prepared in 1952 caused me to question this, and electron photomicrographs made by G. Hendrix (unpublished) further suggest that the trunk cavity, at least, is a true coelom.

The digestive system consists of a large ventral mouth and vestibule opening into a pharynx (sometimes termed esophagus) which extends through the septum between head and trunk and is continuous with the intestine. At the anterior end of the intestine, a pair of lateral diverticula may extend forward toward the septum. The presence or absence of the diverticula is a characteristic used by Alvariño (1969) and others in grouping species which appear to be closely related, e.g., the "*bipunctata*" group (without diverticula) and the "*hispida*" group (with diverticula). In the case of species which inhabit similar environments and are difficult to differentiate until fully mature, such as *Sagitta hispida* and *S. helenae* in the Caribbean area, the presence or absence of the diverticula may be an important characteristic. The intestinal tube, supported by dorsal and ventral mesenteries, extends posteriorly to the ventral anus, located at the end of the trunk and therefore not a terminal aperture.

In contribution of considerable systematic importance, Dallot (1970) called attention to the lack of information on the structure of the intestine. He distinguished between the common simple type and a more complex type, characterized by voluminous vacuolar cells in the intestinal wall, which he compared in nine species. These are *Sagitta bedoti* Beraneck, 1895; *S. decipiens* Fowler, 1905; *S. elegans* Verrill, 1873; *S. megalophthalma* Dallot and Ducret, 1969; *S. marri* David, 1956; *S. minima* Grassi, 1881; *S. neodecipiens* Tokioka, 1959; *S. planctonis* Steinhaus, 1896; and *S. zetesios* Fowler, 1905. I have found this characteristic useful in identifying immature *S. planctonis* forma *zetesios*, as explained in the comments on that form.

The paired ovaries, oviducts, vaginas, and seminal receptacles are located in the trunk coelom, one set on either side of the intestine. The length of the mature ovary and sometimes the size and shape of the mature eggs, though transitory features, are occasionally used in identification. The paired testes and sperm ducts are similarly located in the tail coelom. Sperm pass from the ducts into external structures, the seminal vesicles, where they are formed into spermatophores and stored until released for fertilization. The shape of the mature vesicles as well as their location with respect to lateral and caudal fins are reliable taxonomic characteristics.

Methods

The routine preservatives used for chaetognaths are 70% alcohol or 5-10% Formalin, the latter being far superior. All samples in the Caribbean collections were preserved immediately after arrival on shipboard in 10% Formalin, buffered with hexamethylene tetramine. This buffer is no longer recommended because it adversely affects both external fine structure and internal anatomy in copepods and other planktonic animals. Borax is the preferred buffer.

The equipment needed for working with chaetognaths is a dissecting microscope for general viewing; a compound microscope for examining teeth and other small structures; a wide-mouth pipette, e.g., a medicine dropper; fine forceps; and a pair of fine dissecting needles. A stainless steel needle or size 000 insect pin (head removed), with the shank inserted into a wooden stick, makes a good needle. Specimens should always be totally immersed in fluid, whether in a dish or on a slide with cover slip. Strong transmitted light should regularly be used in making observations with a dissecting microscope. Although staining is rarely necessary for identification, some workers use solutions of aniline blue or methylene blue, mainly to see the corona ciliata and the fins.

Most observations and measurements can be made using a dissecting microscope equipped with an ocular micrometer. Large specimens may be more conveniently measured using a transparent metric rule. Their hooks and even their teeth can often be counted with the magnification provided by a dissecting microscope. If higher magnification is required, the specimen must be mounted on a slide ventral side up, in fluid, and covered in order to count the teeth with the use of a compound microscope. Occasionally an animal will contract so that a dorsal view of the head is also required to enumerate the teeth accurately.

Maturity in chaetognaths is signaled by the presence of ovaries containing large eggs, testes producing spermatozoa, and seminal vesicles, the form and position of which are diagnostic in many species. If the animal has recently discharged spermatozoa, the vesicles will be more or less transparent, but the outline of the adult structure can usually be seen.

Although mature animals are the easiest to identify, it is quite possible to classify most immature specimens, except for tiny juveniles, by using combinations of several characteristics. It is helpful to know the habitat from which the specimen came, planktonic or benthonic, neritic or oceanic, and, if oceanic, from what depth. A generic diagnosis can readily be made by determining the number and position of lateral fins and whether or not they are supported by rays, the presence or absence of a collarette, and the number of rows of teeth. Usually specific identification of an immature form can then be made by measuring the total length and finding the percentage that the tail occupies, examining and counting teeth and hooks, and observing such features as presence or absence of intestinal diverticula and collarette and, if necessary, the shape and extent of the corona ciliata.

Caution must be used in drawing conclusions based on fine differences in measurements of soft parts of specimens from different collections. Ahlstrom and Thrailkill (1962) reported that samples lose 15-87% of their volume at collection, most of it in the first 24 h after preservation. Shrinkage continues over a varying period, with comparative stability reached in 1 to 2 yr. Owre (1973), in discussing the T% relationship, pointed out that in the known developmental patterns of chaetognaths, the T% is higher in small specimens and gradually lessens as the animals mature. The variation expressed as ranges in T% is a function not only of individual difference but also of methods of preservation, time in preservative, and precision in measuring. Owre used measurements of two groups of the small species *Krohnitta pacifica*, preserved for over 2 yr, to demonstrate the inconsistency of the relationship. This is also illustrated by data on *Eukrohnia bathy-*

pelagica, in which the T% appears to be least (25%) in the smallest individuals and increases with length until it reaches the broad range of 27-34% in medium-sized organisms.

It would be impractical to attempt constructing a key to immature forms because the meristic characters which must be combined for a diagnosis change with age. Thus, the present key is intended for the identification of relatively undamaged, mature specimens, although it will work for immature forms of many species. Students who keep the specimen completely immersed and learn to manipulate it and the illumination to show fins and other structures, should be able to make correct identifications. However, novices must always take the precaution of verifying their identification by consulting a description of the species.

Taxonomy

Except for descriptions of new species, the taxonomy within the Phylum Chaetognatha remained essentially the same as that published in Ritter-Záhony's revision (1911a) until Tokioka's (1965a) expanded classification appeared. Rather than establish formal taxa, several workers formed groups of species intended to express relationships, particularly within the largest genus, *Sagitta*. Alvariño (1965) summarized 10 of these and later (1969) presented her own list of groups within *Sagitta*. In general, these groups are disparate and have resulted in little advancement of our knowledge of relationships within the phylum because of the lack of agreement among specialists as to which characteristics are valid both taxonomically and phylogenetically. As the group is largely homogeneous in major anatomical features, a simple classification of genera and species, without supercategories, has sufficed for the purpose of identification.

Claus and Grobben (1905) erected the Class Sagittoidea to include the species then known, all of which were extant. In the only formal presentation of an enlarged classification, Tokioka (1965a) proposed a second class, two orders, two suborders, five families, and six new genera. To include the fossil species *Amiskwia sagittiformis* Walcott, 1911, Tokioka created the Class Archisagittoidea, although Owre and Bayer (1962) had recommended removing it from the Chaetognatha to the Nemertinea and this view received the approval of both Ghirardelli (1968) and Beklemishev (1969). Tokioka joined the new families Spadellidae (*Spadella*) and Eukrohniidae (*Eukrohnia*, *Heterokrohnia*, and *Bathyspadella*) in the Order Phragmophora, characterized by the presence of ventral transverse musculature and greater or lesser development of glandular structures on the body surface, particularly in the cephalic and neck regions. The Order Aphragmophora was erected for those forms lacking ventral transverse musculature, with little or no development of glandular structures on the body surface. The Suborder Ctenodontina (gently curved hooks, comb-shaped tooth rows, and slender teeth) includes the Family Sagittidae Claus and Grobben 1905, and the new Family Pterosagittidae, represented by *Pterosagitta draco*. The Suborder Flabellodontina (relatively abruptly curved hooks, with stouter teeth than in the Ctenodontina, arranged in a fan shape) contains the new Family Krohnittidae and the genus *Krohnitta*. As workers are not obliged to use the supertaxa, the aspect of Tokioka's classification which commands the most attention is the partition of *Sagitta* into nine genera: *Sagitta* sensu strictu; *Serratosagitta* and *Aidanosagitta*, erected by Tokioka and Panthansali in 1963; and Tokioka's new genera in 1965, *Zonosagitta*, *Parasagitta*, *Mesosagitta*, *Solidosagitta*, *Caecosagitta*, and *Flaccisagitta*. The separations are based largely on the structure of the corona ciliata, presence or absence of intestinal diverticula, distribution of rays in the lateral fins, the degree of pigmentation of the eyes, and characteristics of the seminal vesicles.

Tokioka (1965b) used his scheme of classification as a framework to express his views of phylogenetic relationships within this ancient, enigmatic group. In summary, benthic Phragmophora gave rise to bathypelagic phragmophores as well as neritic Aphragmophora, from which oceanic aphragmophore species living in epipelagic, mesopelagic, and bathypelagic realms evolved. Ducret's (1977) intricate study of chaetognath eyes has lent support to Tokioka's views.

The objective of the present work is to enable the student to identify species of chaetognaths in the southwestern North Atlantic, the Florida Straits, the Gulf of Mexico, and the Caribbean Sea. Since most authors of ecological works involving chaetognaths continue to use the simple classification of Ritter-Záhony (1911a, b), also employed by Hyman (1959), Ghirardelli (1968), Alvariño (1967, 1969), and others, the genus *Sagitta* as defined by Ritter-Záhony will be used here.

The common pelagic genera *Eukrohnia*, *Krohnitta*, and *Sagitta* and the benthic *Spadella* contain the majority of the approximately 70 species known. The monospecific *Pterosagitta draco* occurs in abundance in the upper layers of temperate and tropical oceanic waters. Five other genera have been described, three of which are monospecific: *Zahonya* (*Z. cestoda* Oye, 1918), of doubtful validity (Tokioka, 1965a), *Bathyspadella* (*B. edentata* Tokioka, 1939), and *Bathybelos* (*B. typhlops* Owre, 1973). Two species of *Krohnittella* Germain and Joubin, 1912, are known, *K. boureei* Germain and Joubin, 1912, from two specimens, and *K. tokiokai* Bieri, 1974, from one specimen. Bieri (1974) believed this genus may be bathybenthic. The bathypelagic *Heterokrohnia* Ritter-Záhony, 1911a, was described from Antarctic material (*H. mirabilis* Ritter-Záhony, 1911a). *Heterokrohnia mirabilis* has since been reported from the Antarctic (David 1958b) and elsewhere (Tchindonova 1955; Bieri 1959; Dawson 1968). Two other species of *Heterokrohnia* are known, *H. bathybia* Marumo and Kitou, 1966, and *H. involucrum* Dawson, 1968.

The 6 genera and 28 species, known to occur in the Caribbean Sea, the Gulf of Mexico, and the southwestern North Atlantic and treated here, are named in the following list.

List of Species

Class Sagittoidea Claus and Grobben, 1905
Order Phragmophora Tokioka, 1965a
Family Spadellidae Tokioka, 1965a
Spadella Langerhans, 1880
Spadella cephaloptera (Busch, 1851)
S. nana Owre, 1963
S. pulchella Owre, 1963
S. schizoptera Conant, 1895
Family Eukrohniidae Tokioka, 1965a
Eukrohnia Ritter-Záhony, 1909
Eukrohnia bathyantarctica David, 1958
E. bathypelagica Alvariño, 1962
E. fowleri Ritter-Záhony, 1909
E. hamata (Möbius, 1875)
E. proboscidea Furnestin and Ducret, 1965
Order Aphragmophora Tokioka, 1965a
Suborder Ctenodontina Tokioka, 1965a
Family Sagittidae Claus and Grobben, 1905
Bathybelos Owre, 1973
B. typhlops Owre, 1973
Sagitta Quoy and Gaimard, 1827
Sagitta bipunctata Quoy and Gaimard, 1827
S. decipiens Fowler, 1905
S. enflata Grassi, 1881
S. friderici Ritter-Záhony, 1911
S. helenae Ritter-Záhony, 1910
S. hexaptera d'Orbigny, 1843
S. hispida Conant, 1895
S. lyra Krohn, 1853
S. macrocephala Fowler, 1905
S. megalophthalma Dallot and Ducret, 1969
S. minima Grassi, 1881
S. planctonis forma *planctonis* Steinhaus, 1896
S. planctonis forma *zetesios* Fowler, 1905
S. serratodentata Krohn, 1853
S. tenuis Conant, 1896
Family Pterosagittidae Tokioka, 1965a
Pterosagitta Costa, 1869
P. draco (Krohn, 1853)
Suborder Flabellodontina Tokioka, 1965a
Family Krohnittidae Tokioka, 1965a
Krohnitta Ritter-Záhony, 1910
Krohnitta pacifica (Aida, 1897)
K. subtilis (Grassi, 1881)

KEY TO MATURE CHAETOGNATHA

1a. A single pair of lateral fins, which may be short (Fig. 40) or elongate (Fig. 11) or bilobed, owing to the development of seminal receptacles (Fig. 8). . . . 2
1b. Two pairs of lateral fins (Figs. 2, 18). . . . 13
2a. Lateral fins confined to the caudal segment; with a thick collarette extending from neck to fins in undamaged specimens (Fig. 5). . . . *Pterosagitta draco* p. 29
2b. Lateral fins extending along portions of both caudal and trunk segments (Figs. 8, 40). . . . 3
3a. With a more or less prominent collarette; benthic animals of the genus *Spadella*. . . . 4
3b. Without a collarette; planktonic animals. . . . 7
4a. With digitate or irregularly shaped adhesive structures on the tail (Fig. 8). . . . 5
4b. Without such adhesive structures but with adhesive glands on the ventral surface of the tail (Fig. 6). . . . *Spadella cephaloptera* p. 10
5a. Adhesive structures originate from the posterior edge of the seminal vesicles, are attached laterally, and are confluent with the caudal fin (Fig. 7b). . . . *Spadella pulchella* p. 11
5b. Adhesive structures extend from the ventral body wall or the posterior portion of the lateral fins or both, not from the posterior edge of the seminal vesicles. . . . 6
6a. Each adhesive structure is divided into four to six slender processes (Figs. 7a, 8). . . . *Spadella schizoptera* p. 13
6b. Each adhesive structure is divided into two slender processes, or, in very small specimens, the structure may be undivided (Fig. 7c). . . . *Spadella nana* p. 11
7a. Lateral fins extending anteriorly to the level of the ventral ganglion (Fig. 11); hooks usually serrated in juveniles. *Eukrohnia* . . . 8
7b. Lateral fins not extending far anteriorly, never to the ventral ganglion (Fig. 40); hooks not serrated. *Krohnitta* . . . 12
8a. Eyes pigmented, only slightly in some species. . . . 9
8b. Eyes without pigment. . . . 10
9a. Eye pigment covering a small area which, in some specimens, is approximately triangular in shape; tip of hooks gently curved (Fig. 11). . . . *Eukrohnia fowleri* p. 14
9b. Eye pigment forming a very elongated spot; tips of hooks themselves sharply hooked (Fig. 14). . . . *Eukrohnia proboscidea* p. 16
10a. No more than 10 hooks, the tips of which are themselves hooked; teeth usually 18-25 . . . 11
10b. Hooks 11-14, with gently curved tips; teeth 16 or fewer (Fig. 9). . . . *Eukrohnia bathyantarctica* p. 13
11a. Tail, excluding fin, relatively short, occupying 19-24% of the length of animals ranging from 43 to 11 mm (Fig. 12). . . . *Eukrohnia hamata* p. 15
11b. Tail proportionately much longer than in *E. hamata*, occupying 24-34% of the length of specimens 23-12 mm long (Fig. 10). . . . *Eukrohnia bathypelagica* p. 14

12a. Relatively short, to 9 mm, with the caudal segment comprising < 30% of the total length; ovaries of mature specimens extending well beyond the anterior edge of the lateral fins, often to the level of the ventral ganglion (Fig. 40). ..... *Krohnitta pacifica* p. 29

12b. Longer, to approximately 16 mm, with a long tail comprising 30-40% of the total length; mature ovaries usually not extending beyond the anterior edge of the lateral fins but if so, for only a short distance (Fig. 41). ..... *Krohnitta subtilis* p. 30

13a. The two pairs of lateral fins supported to some extent by stiffening rods or rays (Fig. 25); eyes pigmented (exception: *Sagitta macrocephala*, 27b, Fig. 28). *Sagitta* 14

13b. The lateral fins rayless; eyes either altogether absent or lacking pigment; bathypelagic (Figs. 16, 17). ..... *Bathybelos typhlops* p. 17

14a. Body broad, inflated, and translucent, owing to comparatively weak development of longitudinal muscle bands; mature specimens large, approximately 15-40 mm long (Figs. 20, 25, 27). 15

14b. Body comparatively slender, rigid, and opaque (Figs. 18,26); mature specimens of most species < 20 mm long (exceptions: *Sagitta planctonis*, 19 a and b, and *S. megalophthalma*, 20 a, Figs. 30, 35). 17

15a. One to four, usually three, very long slender anterior teeth (Fig. 25). ..... *Sagitta hexaptera* p. 21

15b. Anterior teeth not especially long and slender. 16

16a. Anterior and posterior lateral fins connected by an area of thickened epidermis (Fig. 27) ..... *Sagitta lyra* p. 22

16b. Lateral fins not connected by thickened epidermis but separate, rounded, and short (Fig. 20). ..... *Sagitta enflata* p. 18

17a. With a well-developed collarette (Figs. 35, 36). 18

17b. Collarette either very small or lacking. 25

18a. A prominent collarette of more or less uniform thickness throughout, extending at least from neck to anterior fins in mature forms but often less extensive in immature specimens (e.g., *S. planctonis* forma *zetesios*); intestinal walls characterized by voluminous vacuolar cells which are easily discernible through the body wall. 19

18b. Collarette not extending to the anterior fins. 20

19a. Posterior teeth usually < 14; an epi-mesoplanktonic form[3] (Fig. 35). ..... *Sagitta planctonis* forma *planctonis* p. 26

19b. Posterior teeth usually more than 14; a meso-bathypelagic form (footnote 3) (Fig. 36). ..... *Sagitta planctonis* forma *zetesios* p. 27

20a. Pigmented zone of the eye approximately rectangular and unusually large; 3-4 rows of vacuolar cells on each side of the intestine; total length may exceed 20 mm (Figs. 30-33). ..... *Sagitta megalophthalma* p. 24

20b. Pigmented zone of the eye not unusually large; intestinal walls of the simple type, without conspicuous vacuolar cells; total length at maturity usually < 20 mm 21

21a. Anterior teeth unusually numerous, e.g., 8-10 in 6-7 mm specimens, 15-17 in 14-15 mm specimens; intestinal diverticula absent (Figs. 23, 24). ..... *Sagitta helenae* p. 20

21b. Anterior teeth not as numerous as in *S. helenae*. 22

22a. Seminal vesicles adjacent to the caudal fin and separated from the posterior lateral fins; 4-7 anterior teeth, with their bases closely spaced tangents along an arc roughly at right angles to the longitudinal body axis and their axes radiating in a fan-like arrangement; intestinal diverticula absent (Fig. 18). ..... *Sagitta bipunctata* p. 17

22b. Seminal vesicles adjacent to the posterior lateral fins; anterior teeth not arranged as in *S. bipunctata* 23

23a. A stout primarily neritic species with a well-developed collarette; seminal vesicle separated by about half its mature length from the caudal fin; intestinal diverticula present (Fig. 26). ..... *Sagitta hispida* p. 21

23b. Slender neritic species, with a small collarette in the neck region; mature seminal vesicles extending to both posterior lateral and caudal fins; intestinal diverticula absent 24

24a. A short species, mature at 5-8 mm and rarely exceeding 8 mm in length; mature ovary short, containing a few, usually < 10, large ova, arranged in a single row (Fig. 39). ..... *Sagitta tenuis* p. 28

24b. A longer species, reaching approximately 13.5 mm and maturing at a larger size than *S. tenuis*; mature ovary longer than in *S. tenuis*, containing many small ova, arranged in two or more rows (Figs. 21, 22). ..... *Sagitta friderici* p. 19

25a. Hooks usually 6-7 on each side, finely serrated; in mature specimens, distinctive, projecting, seminal vesicles, well separated from the caudal fin (Figs. 37, 38). ..... *Sagitta serratodentata* p. 27

25b. Hooks not serrated. 26

26a. A small species, no longer than 9 mm; ova few and very large in mature ovaries, which do not extend beyond the anterior edge of the posterior lateral fins; ovoid seminal vesicles adjacent to caudal fins; anterior fins narrow and mostly rayless; rays of posterior fins usually perpendicular to the body wall (Fig. 34). ..... *Sagitta minima* p. 25

26b. Without the characteristics of *S. minima*. 27

27a. A species with a relatively small head; anterior fin extending to the ventral ganglion and usually rayless in the anterior portion; posterior fin relatively broad; pigmented eyes of mature specimens distinctly elongated (Fig. 19). ..... *Sagitta decipiens* p. 18

27b. A species distinguished by an exceptionally large head, longer than broad, with numerous dark brown hooks and teeth; eyes without pigment; anterior fin short, not extending to the ventral ganglion; posterior fin much larger than the anterior, with an inner rayless zone (Figs. 28, 29). ..... *Sagitta macrocephala* p. 23

[3]From David (1956) and Pierrot-Bults (1975).

DESCRIPTIONS AND DISTRIBUTIONS

An abbreviated synonymy and brief description of each species is followed by a summary of information on its distribution within the specified areas. Michel et al. (1976) discussed vertical distribution of pelagic forms in detail. Some of the data on which the discussion was based are included in Tables 2 and 3. The only neritic species found in that study of oceanic regions, *Sagitta helenae* and *S. hispida*, were strays which had been transported from nearshore environments. They, with *S. friderici* and *S. tenuis*, also common neritic forms in the area, are ordinarily epipelagic when found in oceanic waters. However, *S. helenae*, *S. hispida*, and *S. tenuis* have been collected at more than 650 m in the Florida Straits, indicating entrainment of surface waters in the deep flow beneath the Florida Current (Stepien 1980).

Although most oceanic species have broad vertical ranges, their greatest numbers are found over a comparatively limited distance (Table 2). As Michel et al. (1976) pointed out, some records of epipelagic species at relatively great depths no doubt result from contamination. However, during their study, special precautions were taken to eliminate from the counts desiccated specimens and those obviously moribund at preservation. It appears that at least some of the deep records are real, as Stepien (1980) found, although they may be difficult to interpret. In Table 3, all of the species collected are arranged in order of their occurrence in relation to the broad ranges in depth termed epi-, meso-, and bathypelagic realms.

Throughout the reports of vertical distribution in the Caribbean area, reference will be made to the water masses from which the species have been collected. A summary of the general characteristics of depth, temperature, and salinity of these water masses follows. The Tropical Surface Water (TSW) forms the upper 50-100 m and, because of precipitation and evaporation, is broadly variable in temperature (approximately 22°-29°C) and salinity (33-38$^0/_{00}$). The Subtropical Underwater (SUW), or Maximum Salinity Water, beneath the TSW at approximately 100-200 m, has salinities above 36.25$^0/_{00}$ and temperatures usually < 26°C. North Atlantic Central Water (NACW), characterized by gradually diminishing temperature and salinity, extends between SUW and the colder, less saline (5°-8°C, 34.69-35.12$^0/_{00}$) Subantarctic Intermediate Water (SAIW). This water mass is found at approximately 700-1,200 m, below which North Atlantic Deep Water (NADW) and Caribbean Bottom Water (BW) fill the basins.

Table 3.—Vertical distribution of Chaetognatha in the Caribbean Sea and adjacent regions, with species arranged in order of frequency of occurrence from the surface to depths below 1,000 m and showing the estimated total numbers, derived from counts of some entire samples and aliquots of others, collected in the epi-, meso-, and bathypelagic realms (after Michel et al. 1976.).

Species	0-200 m		201-1,000 m		>1,000 m	
	No.	%	No.	%	No.	%
Sagitta helenae	14	100.0	—	—	—	—
S. enflata	57,683	99.8	112	<1	—	—
Pterosagitta draco	11,701	99.8	16	<1	2	<1
S. serratodentata	31,047	99.1	284	<1	6	<1
Krohnitta pacifica	4,729	99.0	33	<1	2	<1
S. hispida	1,119	98.9	12	1.1	—	—
S. hexaptera	8,827	92.4	718	7.5	4	<1
S. bipunctata	1,987	92.0	175	8.0	—	—
S. megalophthalma	7	88.0	—	—	1	12.0
S. minima	110	67.0	55	33.0	—	—
K. subtilis	1,342	38.0	2,148	61.0	5	1.0
S. lyra	964	27.0	2,534	72.0	31	1.0
S. planctonis forma *zetesios*	13	19.0	53	77.0	3	4.0
S. decipiens	875	6.6	12,300	93.0	8	<1
E. hamata	—	—	17	100.0	—	—
S. planctonis forma *planctonis*	—	—	1	100.0	—	—
E. bathypelagica	—	—	247	92.0	23	8.0
E. bathyantarctica	—	—	214	78.0	61	22.0
E. fowleri	—	—	147	75.0	48	25.0
E. proboscidea	—	—	3	60.0	2	40.0
S. macrocephala	—	—	270	57.0	201	43.0
Bathybelos typhlops	—	—	—	—	1	100.0

Table 2.—Summary of the vertical ranges of the more common chaetognath species in the Caribbean Sea and adjacent regions, the total number of samples in which each occurred, the estimated total number collected, and the average number per sample obtained in the standard hour-long tow (after Michel et al. 1976). The estimated total numbers of each species and the average number per sample are based on counts of some entire samples and aliquots of others.

	Total range (m)	Range of maximum numbers (m)	Number of samples	Total est. numbers	Avg. no./ sample
"Epipelagic" species					
K. pacifica	0-1,835	0-100	69	4,762	69.0
P. draco	0-2,316	0-100	50	11,717	234.3
S. bipunctata	0-300	0-100	34	2,162	63.6
S. enflata	0-320	0-100	95	57,795	608.4
S. serratodentata	0-2,000	0-100	102	31,331	307.2
S. hexaptera	0-1,567	0-200	91	9,545	104.9
S hispida	0-250	0-60	33	1,131	34.3
S. minima	0-590	—	8	165	20.6
"Mesopelagic" species					
K. subtilis	25-5,200	100-500	71	3,495	49.2
S. decipiens	75-2,650	200-500	90	13,183	146.5
S. lyra	25-3,000	200-600	104	3,529	33.9
S. planctonis forma *zetesios*	38-3,000	250-1,000	27	69	2.5
"Bathypelagic" species					
E. bathyantarctica	230-3,442	500-2,000	44	275	6.2
E. bathypelagica	433-2,118	450-1,000	47	270	5.7
E. fowleri	635-2,104	635-2,104	55	195	3.5
S. macrocephala	472-3,602	600-2,500	106	471	4.4

NADW is identified by temperatures below 5°C and salinities of 34.89 to 35.03‰.

One enigmatic planktonic species has been found in the area, *Bathybelos typhlops*, described by Owre (1973) from one specimen collected in deep water of the eastern Gulf of Mexico. Four species occurring in small numbers probably are indicators of North Atlantic waters: *Eukrohnia hamata*, *E. proboscidea*, *Sagitta megalophthalma*, and *S. planctonis* forma *planctonis*. All four were collected in the Caribbean, and, excepting *E. proboscidea*, have been reported from the Florida Straits (*E. hamata* and *S. planctonis* by Owre 1960; *E. hamata* and *S. megalophthalma* by Stepien 1980). The neritic species *Sagitta tenuis* and *S. friderici* appear to have discontinuous geographic distributions which are discussed under the species headings. The remaining species are widely distributed and common at their primary depths of occurrence. Previous records are summarized in Table 4.

Three of the four species of *Spadella* known from the western North Atlantic have been reported as common on shallow sandy bottoms around the Bahama Islands and off the southeast coast of Florida (Owre 1963, 1972b). *Spadella pulchella*, described from Puerto Rican specimens, was collected in the Bahamas but not off Florida. The distribution of these organisms in the Caribbean, the Gulf of Mexico, and the western North Atlantic is essentially unknown.

Table 4.—Previous records of chaetognath species from the Caribbean Sea, the Gulf of Mexico, the Florida Straits, and the southwestern North Atlantic. Additional records of Atlantic distribution have been summarized by Alvariño (1969) and Michel et al. (1976) (after Stepien 1978).

Species	Caribbean Sea[1]	Gulf of Mexico[2]	Florida Straits[3]	Southwestern North Atlantic[4]
Eukrohnia bathyantarctica	+	+	+	+
E. bathypelagica	+	+	+	–
E. fowleri	+	+	+	+
E. hamata	+	+	+	+
E. proboscidea	+	–	–	–
Krohnitta pacifica	+	+	+	+
K. subtilis	+	+	+	+
Pterosagitta draco	+	+	+	+
Sagitta bipunctata	+	+	+	+
S. decipiens	+	+	+	+
S. enflata	+	+	+	+
S. friderici	+	+	–	–
S. helenae	+	+	+	+
S. hexaptera	+	+	+	+
S. hispida	+	+	+	+
S. lyra	+	+	+	+
S. macrocephala	+	+	+	+
S. megalophthalma	+	–	+	–
S. minima	+	+	+	+
S. planctonis forma *planctonis*	+	–	+	+
S. planctonis forma *zetesios*	+	–	+	+
S. serratodentata	+	+	+	+
S. tenuis	+	+	+	+

[1]Vannucci and Hosoé (1952); Suárez-Caabro (1955); Colman (1959); Suárez-Caabro and Madruga (1960); Legaré and Zoppi (1961); Alvariño (1968a); Fagetti (1968); Lewis and Fish (1969); Björnberg (1971); Owre (1972a, 1973); Owre and Foyo (1972); Mattlin (1974); Urosa and Rao (1974); Michel et al. (1976).

[2]Davis (1949); King (1949); Pierce (1951, 1954, 1962); Every (1968); Fagetti (1968); Mulkana and McIlwain (1973); Owre (1973); McLelland (1978).

[3]Owre (1960); Stepien (1978).

[4]Moore (1949); Pierce (1953, 1958); Bumpus and Pierce (1955); Colman (1959); Pierce and Wass (1962); Grant (1963a, b, 1977); Deevey and Brooks (1971); Pierrot-Bults (1975, 1982).

Spadella cephaloptera (Busch, 1851)

Figure 6

Sagitta cephaloptera Busch, 1851.

Spadella cephaloptera, Ritter-Záhony, 1911a; Yosii and Tokioka, 1939; Owre, 1972b.

Description. Length, to 9.5 mm, usually 2-4 mm in Floridian and Bahamian waters; T%, 49-58; hooks, 7-11; anterior teeth, 2-5; posterior teeth, 0-4. Collarette, thickest at neck, extends to

Figure 6.—*Spadella cephaloptera*, dorsal view.

caudal fin. Oval corona ciliata is located on head and trunk. A single pair of lateral fins is present; there are no adhesive structures.

Distribution. Long known from British and European coasts and the Mediterranean, and also reported from the Black Sea, Japan, and the Caroline Islands, it appears to be cosmopolitan in temperate and tropical seas. It is widespread in shallow Bahamian waters and probably also in comparable habitats off southern Florida (Owre 1972b).

Spadella nana Owre, 1963

Figure 7c

Spadella nana Owre, 1963.
Spadella nana, Tokioka, 1965; Owre, 1972b.

Description. Length, to 2.6 mm; T%, 41-50; hooks, 5-9; anterior teeth, 1-3; posterior teeth, none. Collarette is continuous with hood, thickest at the neck, and it extends along the base of the lateral fin to the seminal vesicle. Corona ciliata, variable in shape, is located on the anterior trunk in the neck region except for the middle portion of its anterior border, which extends onto the posterior part of the head. One pair of lateral fins originates 0.10-0.14 mm anterior to seminal receptacles and terminates just anterior to seminal vesicles. Adhesive structures are produced ventrally from the posterior end of the lateral fins. Each is divided into two relatively stout, distally tuberculate processes which contain muscle fibers originating from both dorsal and ventral longitudinal muscle bands. In very small specimens, the structure may terminate in a single process.

Distribution. *Spadella nana* is abundant in shallow waters of southeastern Florida and the Bahama Islands (Owre 1972b).

Spadella pulchella Owre, 1963

Figure 7b

Spadella pulchella Owre, 1963.
Spadella pulchella, Tokioka, 1965.
Spadella hummelincki Alvariño, 1970.
Spadella pulchella, Owre, 1972b, 1973.

Description. Length, to 3.5 mm; T%, 52-59; hooks, 8-10; anterior teeth, 2-4; posterior teeth, none. Collarette, prominent at the neck and on the anterior trunk, extends along the bases of the lateral fins to a point on the caudal segment approximately 0.5 mm posterior to the transverse septum. Broad, irregularly oval corona ciliata is located anteriorly on the trunk except for a short loop in the middle of the anterior border which extends onto the head. Lateral fins originate approximately 0.07-0.10 mm anterior to the seminal receptacles and reach the seminal vesicles. Adhesive structures do not originate from the lateral fins but extend from the seminal vesicles along the side of the caudal segment to an area of attachment at the base of the caudal fin. In immature forms, these structures may be undivided flanges with irregular posterior borders, whereas in older specimens they may be separated into two or three digitations, with numerous, close-set, distal tuberculations.

Distribution. *Spadella pulchella* was described from specimens collected in a net haul near bottom in the Mayagueyez Canal, La Parguera, Puerto Rico. Since then, Owre (1972b) has reported it from two locations in the Bahama Islands, where it was rare compared with *S. cephaloptera*, *S. nana*, and *S. schizoptera*. Owre suggested that it may prefer more estuarine conditions than the others. There are no records from the continental United States.

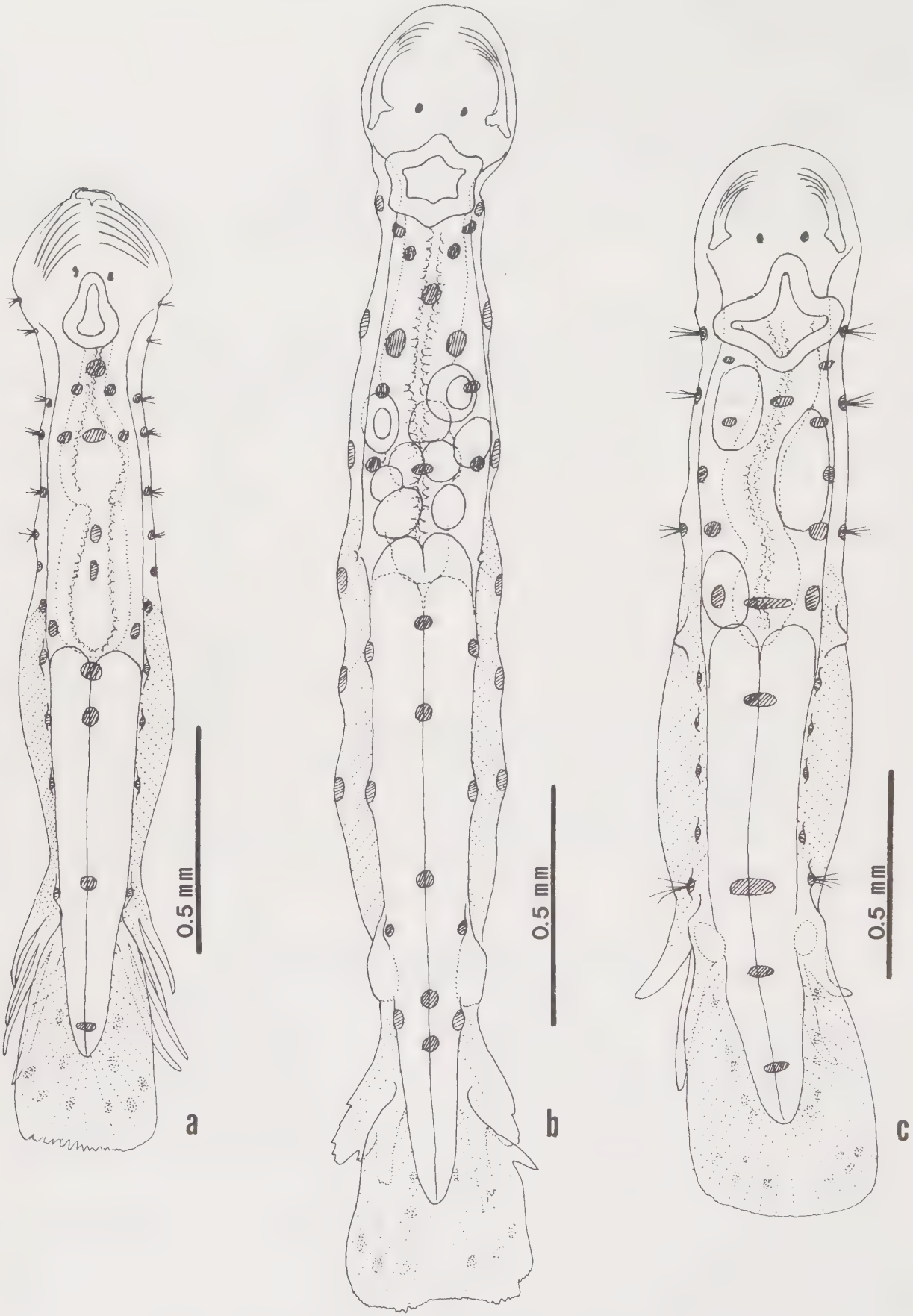

Figure 7.—a. *Spadella schizoptera*, immature; b. *Spadella pulchella*; c. *Spadella nana*; all dorsal view.

Spadella schizoptera Conant, 1895

Figures 7a, 8

Figure 8.—*Spadella schizoptera*, dorsal view.

Spadella schizoptera Conant, 1895.
Spadella schizoptera, Ritter-Záhony, 1911a; Yosii and Tokioka, 1939; Mawson, 1944; Owre, 1963, 1972b; Tokioka 1965a.

Description. Length, to 4.9 mm; T%, 42.0-53.7; hooks, 8-11; anterior teeth, 2-4; posterior teeth, none. A thick collarette is present. Corona ciliata, located mainly on the head, is somewhat triangular or pyriform. Anterior and posterior lateral fins are separated by the conspicuous seminal receptacles and vaginal canals. Posterior lateral fins terminate in adhesive structures which are produced ventrally at the level of the origin of the caudal fin. Each of these is divided into four to six digitiform processes, usually four in Atlantic specimens, which contain muscle fibers originating from either side of the mid-ventral line.

Distribution. Reported from Japan, Australia, Florida, and the Bahama Islands, this species is abundant in the latter two localities, where it appears to prefer sandy bottom, supporting plant growth, at depths of approximately 1-15 m (Owre 1972b). Conant (1895) described the species from three specimens caught in a plankton net on a rising tide at Bimini, Bahamas. In Japan, Yosii and Tokioka (1939) collected one from the same still waters among *Zostera* in which *S. cephaloptera* was abundant. Perhaps the most interesting record is that of Mawson (1944), who redescribed the species from 20 specimens taken at two trawling stations of 70 and 100 m depth off New South Wales. Both bottoms are fine sand, the shallower one with detritus; no algae occur on either bottom.

Eukrohnia bathyantarctica David, 1958

Figure 9

Eukrohnia fowleri (partim), Ritter-Záhony, 1911a.
Eukrohnia sp. David, 1958a.
Eukrohnia bathyantarctica David, 1958b.
Eukrohnia bathyantarctica, Fagetti, 1968; Alvariño, 1969; Owre, 1972a, 1973.

Description. Length, to 31 mm; T%, 19.3-25.0; hooks, 9-14; teeth, 2-16. Owre (1973) found the inner distal margin of some ventral hooks in immature individuals, measuring 7.5-12.0 mm, to be deeply serrated. The number of serrated hooks and also the number of serrations on each hook are greater in smaller animals.

Figure 9.—*Eukrohnia bathyantarctica*, dorsal view.

There is no collarette, and the corona ciliata has not been described. Eyes are unpigmented. Fins extend from the level of the ventral ganglion onto approximately the anterior third of the caudal segment.

There are no intestinal diverticula. Mature ovaries are short, with the ova lying in one row (Fig. 9) or, according to Alvariño (1969), two rows. David (1958b) reported that remnants of seminal vesicles "...project from [the] oviduct after fertilisation." Ovoid seminal vesicles lie close to the lateral fins, separated by a distance approximately equal to their length from the caudal fin.

Distribution. David (1958b) described this species from 1,000 to 2,400 m in the Southern Ocean and considered it endemic in the Antarctic. However, it has a far broader horizontal distribution than originally thought, having been reported from the Caribbean Sea and Gulf of Mexico (Fagetti 1968; Owre 1972a) and from the Straits of Florida (Stepien 1980). In the Caribbean, it has been collected over an extensive vertical range, 230-3,442 m, but primarily from Subantarctic Intermediate Water and North Atlantic Central Water (Michel et al. 1976). As shown in Table 3, it was most numerous in the mesopelagic realm.

Eukrohnia bathypelagica Alvariño, 1962

Figure 10

Figure 10.—*Eukrohnia bathypelagica*, dorsal view.

Eukrohnia bathypelagica Alvariño, 1962.
Eukrohnia bathypelagica, Ducret, 1965; Alvariño, 1969; Figueira, 1972; Owre, 1973.

Description. Length, to 28.2 mm; T%, 25-34; hooks, 7-10, sharply curved at the tip; teeth, 13-22 or possibly more, according to Figueira (1972). Ventral hook or hooks may be serrated on the inner distal margin (Owre 1973). There is no collarette in the neck region, but collarette-type epidermal tissue occurs from the level of the anterior end of the ventral ganglion to the base of the caudal fin. Corona ciliata has not been described. Eyes lack pigment. Transverse musculature is well developed. Fins extend from a level approximately at the middle of the ventral ganglion onto the anterior half, more or less, of the caudal segment. Although in her description, Alvariño (1962) stated that there is no constriction of the body at the caudal septum, some specimens have such a constriction (Fig. 10), which may result from muscular contraction at death.

There are no intestinal diverticula. Mature ovaries may extend through the posterior half of the trunk, although those of Caribbean specimens are much shorter. Owre's (1973) report of mature ovaries in a 13 mm specimen suggests that there is more than one period of maturation. Ovoid seminal vesicles develop just posterior to the lateral fins and are broadly separated from the caudal fin.

Distribution. *Eukrohnia bathypelagica* is a cosmopolitan mesobathypelagic species described from northern Pacific specimens and since reported from the South China Sea (Alvariño 1967), the Gulf of Guinea (Ducret 1965), the North Atlantic near the Gulf of St. Lawrence (Figueira 1972), the Caribbean Sea and Gulf of Mexico (Owre 1973), and the Florida Straits (Stepien 1980). Michel et al. (1976) collected it in waters 423-2,118 m deep but mainly in Subantarctic Intermediate Water, in the mesopelagic realm (Table 3).

Eukrohnia fowleri Ritter-Záhony, 1909

Figure 11

Krohnia hamata, Fowler, 1905.
Krohnia hamata, Fowler, 1906.
Eukrohnia fowleri Ritter-Záhony, 1909.
Eukrohnia fowleri, Ritter-Záhony, 1911 a, b; Ducret, 1965; Owre, 1960; Alvariño, 1969; Michel, Foyo, and Haagensen, 1976; Stepien, 1980.

Description. Length, to 40 mm; T%, 21-27; hooks, 8-13; teeth, as many as 30. There is no collarette. The rounded apex of the flask-shaped corona ciliata lies between the eyes and the base is situated at the neck. The small pigmented area of the eye may be elongated or triangular. Approximate extent of the lateral fins is from the level of the middle of the ventral ganglion to the middle of the caudal segment.

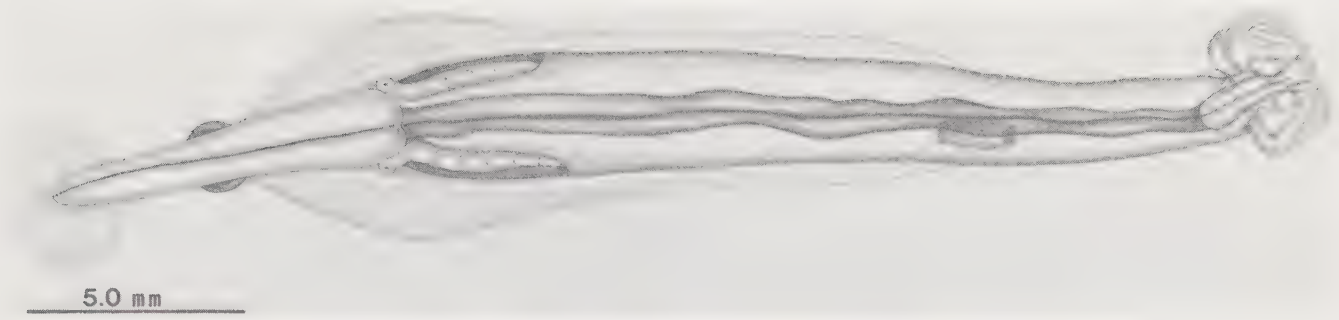

Figure 11.—*Eukrohnia fowleri*, dorsal view.

There are no intestinal diverticula. Mature ovaries are short, with two rows of large ova. Gently curving, somewhat flattened seminal vesicles develop just posterior to the lateral fins, well anterior to the caudal fin.

Distribution. Cosmopolitan below 600 m in tropical and subtropical latitudes, this predominantly mesopelagic species has been reported by Owre (1960) and Stepien (1980) from the Florida Straits. Michel et al. (1976) found it only in Subantarctic Intermediate and North Atlantic Deep Waters in the Caribbean Sea, where it was collected between 635 and 2,104 m. *Sagitta macrocephala* regularly occurred in the same samples.

Eukrohnia hamata (Möbius, 1875)

Figure 12

Sagitta hamata Möbius, 1875.
Krohnia hamata, Langerhans, 1880.
Eukrohnia hamata, Ritter-Záhony, 1909, 1911 a, b; Ducret, 1965; Owre, 1960; Alvariño, 1969; Michel, Foyo, and Haagensen, 1976; Stepien, 1980.

Description. Length, to 43 mm, T%, 19-24; hooks, 8-10; teeth, as many as 25. There is no collarette. The flask-shaped corona ciliata extends onto the trunk. Eyes lack pigment. Lateral fins extend from the mid-level of the ventral ganglion onto at least the anterior third of the caudal segment.

There are no intestinal diverticula. Ovaries are relatively elongate, with small ova arranged in four rows, and the ovoid seminal vesicles develop near the posterior end of the lateral fins (Alvariño, 1969). Specimens collected in lower Atlantic latitudes rarely have reached advanced sexual development.

Distribution. This species has an Atlantic bipolar distribution, with subtropical submergence, being epipelagic in the high latitudes and meso-bathypelagic in the lower ones (David 1958a; Alvariño 1964). Its distribution appears to be regulated mainly by temperature. Owre (1960), noting Fowler's (1907) observation that it had not been recorded from water warmer than 12.7°C, reported it from 225-275 m in the Florida Straits, where the temperature was well below 12°C. In the Caribbean, Michel et al. (1976) found specimens at 715 m (7.2°C) and 822 m (6.5°C). Stepien (1978) regarded its presence in deep currents (625-749 m), always colder than 7°C, in the Florida Straits as "...strong evidence for the presence of Atlantic waters originating in the north" of the study area, due east of Miami, Fla. Having found no trace of resident populations of *E. hamata* in the Caribbean, Michel et al. (1976) speculated that it is an indicator of intrusions of deep North Atlantic water.

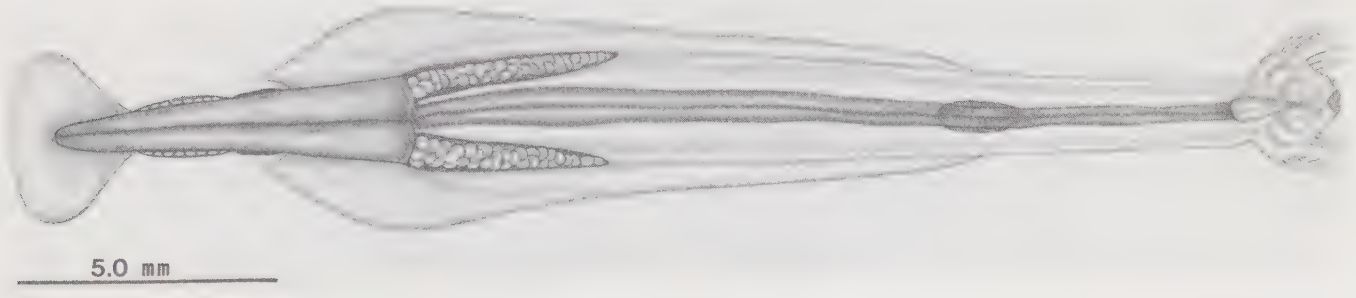

Figure 12.—*Eukrohnia hamata*, dorsal view.

Eukrohnia proboscidea Furnestin and Ducret, 1965

Figures 13, 14, 15

Figure 13.—*Eukrohnia proboscidea*, dorsal view.

Figure 14.—*Eukrohnia proboscidea*, dorsal view of head.

Figure 15.—*Eukrohnia proboscidea*, ventral view of head.

Eukrohnia proboscidea Furnestin and Ducret, 1965.
Eukrohnia proboscidea, Ducret, 1965; Owre, 1973; Michel, Foyo, and Haagensen, 1976.

Description. Length, to 29.5 mm; T%, 20-31.2; hooks, sharply curved at the tip, 10-13; teeth, 8-25. Owre (1973) reported that, in the two smallest specimens she collected, measuring 13.0 and 16.5 mm, the ventralmost hook on each side bears 10-18 serrations on the inner margin. Projecting anteriorly on either side of the distal midline of the head are two clearly separated groups of "apical glands," a characteristic for which the species was named. Eyes are distinguished by a very elongated pigmented area. Although it was stated in the original description that no collarette is present, a marked muscular constriction at the neck causes the epidermis in that region to appear as a discrete layer. The corona ciliata has not been described. Transverse musculature is well developed, especially on the anterior trunk. Fins extend from the level of the ventral ganglion onto the anterior half of the caudal segment and are broadest posterior to the transverse septum.

There are no intestinal diverticula. Mature ovaries are short. Ovoid seminal vesicles lie just posterior to the lateral fins, separated by a distance approximately equal to their length from the caudal fin.

Distribution. *Eukrohnia proboscidea* was described from 55 specimens collected at 1,000 and 1,100 m off southwest Africa. Four specimens were found in Caribbean samples from 739, 750, 1,100, and 2,072 m (Owre 1973; Michel et al. 1976). It is thus a very poorly known species.

Bathybelos typhlops Owre, 1973

Figures 16, 17

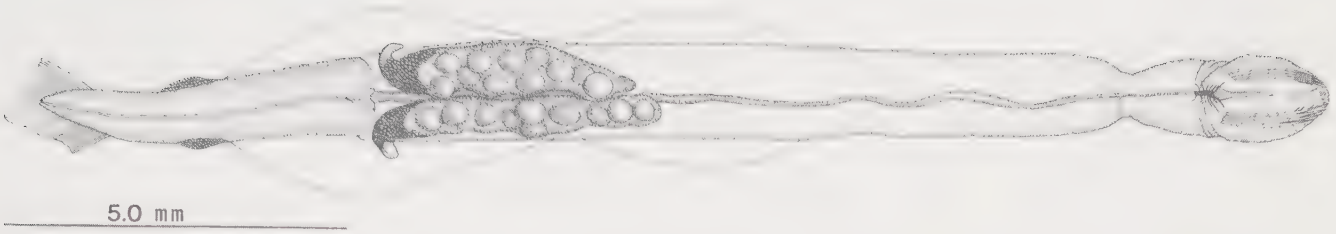

Figure 16.—*Bathybelos typhlops*, dorsal view.

Description. Length, to 17.2 mm; T%, 29; hooks, 9-10; anterior teeth, none; posterior teeth, 13. No traces of eyes or ventral ganglion were found in the one specimen known, but a large rectangular nerve center is located on the dorsal side of the neck. Neither collarette nor corona ciliata is present. Completely rayless anterior and posterior lateral fins are short, evenly rounded, and relatively thick at their bases.

There are no intestinal diverticula. The digestive tube appears to be the type designated as simple by Dallot (1970). Mature ovaries contain at least 10 ova and are approximately 4 mm long. Seminal vesicles are separated from the caudal fin and probably in contact with posterior lateral fins at maturity.

Distribution. The one specimen known was collected from 2,500 m at lat. 25°59′N, long. 86°11′W, in the western Gulf of Mexico (Owre 1973).

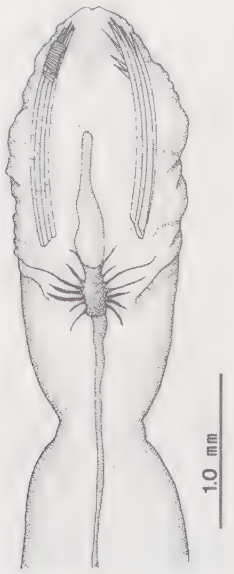

Figure 17.—*Bathybelos typhlops*, dorsal view of head.

Sagitta bipunctata Quoy and Gaimard, 1827

Figure 18

Sagitta bipunctata Quoy and Gaimard, 1827.
Sagitta bipunctata, Ritter-Záhony, 1911a, b; Alvariño, 1969.

Description. Length, to 18.5 mm, usually to 15 mm in the southwestern North Atlantic; T%, 21-28; hooks, 8-10; anterior teeth, 5-8; posterior teeth, 8-16. Collarette is present on the posterior head and anterior trunk, and a thinner layer of thickened epidermis may be observed on the trunk in undamaged specimens. Alvariño (1969) indicated by illustration that this thickening may also be present between the posterior lateral fins and the seminal vesicles. Corona ciliata as described by Ritter-Záhony (1911a) is "... attenuated, at least twice as long as the head, beginning close behind the brain, mostly irregularly sinuous." The lateral fins contain rays throughout their lengths. The anterior pair extends to the

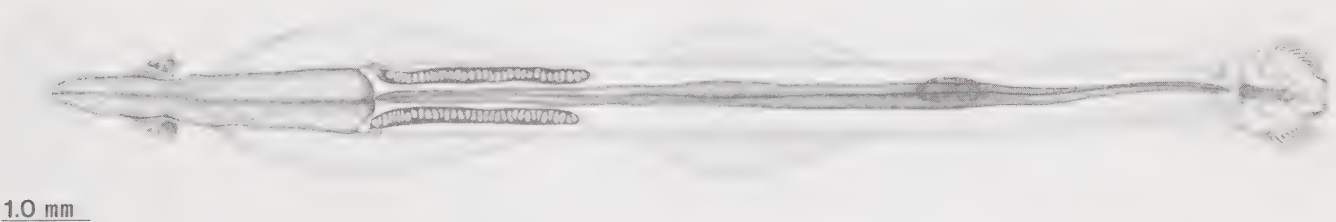

Figure 18.—*Sagitta bipunctata*, dorsal view.

posterior end of the ventral ganglion and is well separated from the posterior pair, which is located approximately equally on trunk and caudal segments.

There are no intestinal diverticula. Mature ovaries usually reach the level of the anterior third of the anterior fins. Mature seminal vesicles develop posterior to the terminus of the posterior fins and extend to the caudal fin. This position and their shape, with a knoblike protrusion at the anterior end, are diagnostic characteristics.

Distribution. *Sagitta bipunctata* is a cosmopolitan oceanic species in temperate and tropical waters. However, records from the western North Atlantic indicate that it is far more numerous in temperate waters, e.g., off Bermuda (Moore 1949; Pierrot-Bults 1982) than in tropical areas (Owre 1960; Michel et al. 1976).

Sagitta decipiens Fowler, 1905

Figure 19

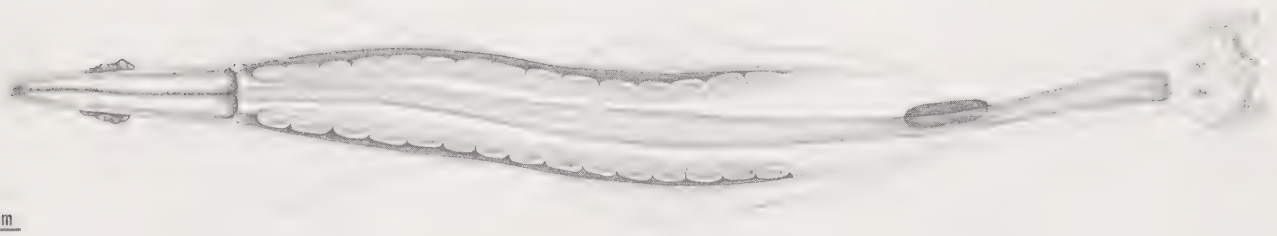

Figure 19.—*Sagitta decipiens*, dorsal view.

Sagitta decipiens Fowler, 1905.
Sagitta sibogae, Fowler, 1906.
Sagitta decipiens, Ritter-Záhony, 1911 a, b; Owre, 1960; Alvariño, 1965, 1969; Michel, Foyo, and Haagensen, 1976.
Sagitta sibogae, Pierrot-Bults, 1979, 1982.

On the basis of specimens collected near Bermuda and alcohol-preserved type material, Pierrot-Bults (1979) concluded that *S. decipiens* Fowler, 1905 and *S. sibogae* Fowler, 1906 are separate species, the former being "deep-mesopelagic" and the latter, "shallow-mesopelagic." The case for the acceptance of *S. sibogae* as a valid species is not convincing at present, owing to the lack of length-related meristic and other comparisons and the possibility that the few differences mentioned may result from age, preservation, or variations associated with depth. Pierrot-Bults (1982) indicated that further information on *S. sibogae* is in preparation. Meanwhile, the opinion of Ritter-Záhony (1911a, b) that *S. sibogae* is a synonym of *S. decipiens* is retained.

Description. Length, to approximately 20 mm; T%, 18-32; hooks, 5-7; anterior teeth, 4-13; posterior teeth, 6-20. The imbricated arrangement of the short, triangular, anterior teeth in rows which curve ventrad toward the midline is characteristic. The collarette is so small that it usually is unobservable. Ritter-Záhony (1911a) illustrated an elongated, sinuous corona ciliata located entirely on the anterior trunk, but this was a reconstruction as he was able to observe only a portion of the structure. The shape of the eye pigment is distinctive in adults. As Ritter-Záhony (1911a) observed, it is rounded in small animals but gradually elongates with growth until it becomes "T"-shaped, with a long lateral portion, oriented anteroposteriorly, and a short bar extending mediad. Anterior fins may reach the posterior end of the ventral ganglion, are relatively narrow, and are rayless anteriorly. Posterior fins are similar but deltoid in shape.

The muscular walls of the pharynx, not shown in Figure 19, and the intestinal diverticula are prominent. Mature ova are large, and the ovaries may reach the level of the anterior one-third, approximately, of the anterior fins. Mature seminal vesicles are not in contact with the lateral fins; their posterior tissues may extend to the origins of the caudal fin.

Distribution. This is a mesopelagic species, cosmopolitan in temperate and tropical latitudes. In the Caribbean region, Michel et al. (1976) reported that numerically it ranked fourth among chaetognaths, after *S. enflata*, *S. serratodentata*, and *Pterosagitta draco*. It occurs mainly between 200 and 1,000 m in Subtropical Underwater and its mixture with North Atlantic Central Water, and it is maximally abundant from 200 to 500 m. Pierrot-Bults (1982) found *S. decipiens* most numerous between 500 and 600 m, and *S. sibogae*, here considered a synonym, between 300 and 400 m, in waters near Bermuda. The materials on which Pierrot-Bults' report is based are one day and one night series of samples collected from approximately the same depths.

Sagitta enflata Grassi, 1881

Figures 2, 20

Sagitta Enflata Grassi, 1881.
Sagitta inflata, Ritter-Záhony, 1908.
Sagitta enflata, Fowler, 1906; Ritter-Záhony, 1911a, b; Alvariño, 1965, 1969.

Figure 20.—*Sagitta enflata*, dorsal view.

Description. Length, to 25 mm; T%, 14-17; hooks, 7-10; anterior teeth, 3-8; posterior teeth, 4-17. Collarette is absent. Corona ciliata lies only on the head and, according to the illustration by Ritter-Záhony (1911b), consists of anterior and posterior loops, with a pair of smaller loops extending laterad from the base of the anterior loop. Anterior and posterior fins are short. The rounded anterior pair is situated far posterior of the ventral ganglion, the posterior pair is deltoid, and rayless areas characterize the inner portions of both.

There are no intestinal diverticula. Mature ovaries may extend to the posterior portion of the anterior fins but usually are shorter. Small, rounded seminal vesicles develop adjacent to the caudal fin, distant from the posterior fins.

Distribution. *Sagitta enflata* is a common epipelagic species worldwide in warmer waters. It is more abundant near land masses than in the open ocean (Owre 1960), and, in the southeastern North Atlantic, it often is carried into neritic waters by tidal movements. Pierce (1951) found a similar distribution in the eastern Gulf of Mexico. An inhabitant of Tropical Surface Water and upper Subtropical Underwater, it is the most numerous oceanic chaetognath species in the Caribbean region and the Gulf of Mexico (Michel et al. 1976).

Sagitta friderici Ritter-Záhony, 1911

Figures 21, 22

Figure 21.—*Sagitta friderici*, dorsal view.

Sagitta friderici Ritter-Záhony, 1911a.

Sagitta friderici, Faure, 1952; Vannucci and Hosoé, 1952; Tokioka, 1955, 1961; Almeida Prado, 1961, 1968; Laguarda-Figueras, 1967; McLelland, 1980.

Description. Length, to 13.5 mm; T%, 25-30; hooks, 7-9; anterior teeth, 6-10; posterior teeth, 12-23. Collarette is present in the neck region and on the upper trunk. Undulating, elongate corona ciliata extends from a level anterior to the eyes to a point approximately two-thirds of the length between the neck and the ventral ganglion (Tokioka 1961). The fins are supported throughout their extent by rays. The anterior fins extend to the posterior end of the ventral ganglion. More of the posterior fin is situated on the caudal segment than on the trunk, and it is broadest posterior to the septum.

There are no intestinal diverticula. The ovaries are elongated and, when fully developed, may extend to the level of the ventral ganglion. The ova are small, numerous, and arranged in two or

Figure 22.—*Sagitta friderici*, ventral view of head.

more rows. Mature seminal vesicles lie in proximity to both posterior and caudal fins.

Distribution. Knowledge of the occurrence of this neritic species in the Caribbean area is limited. Vannucci and Hosoé (1952) reported it from Atlantic waters near Trinidad, and Laguarda-Figueras (1967), from Laguna de Terminos in the southwestern Gulf of Mexico. Mattlin (1974) found one specimen in a surface sample from the Gulf of Cariaco (7.5 mm long, T% 30, hooks 8-8; anterior teeth 7-7, posterior teeth 15-16, immature, with slight development of seminal vesicles). In an important study of chaetognaths in the shelf and slope waters in the northeastern Gulf of Mexico, McLelland (1978) collected *S. friderici* at all except one station near the 200-fathom contour and reported that it was second in abundance, *S. enflata* being the most numerous species. It "...showed a marked preference for lower salinity surface waters..." and "...was the dominant chaetognath in the upper strata of the water column over the continental shelf..." It was collected over a wide range of temperature and salinity but was more commonly found in waters of $< 34^{0}/_{00}$ and $> 23°C$.

Sagitta friderici has not been reported from the east coast of North America. In the Gulf of Mexico, it probably has often been confused with the similar but smaller species, *Sagitta tenuis*. The validity of *S. friderici* has been supported by numerous specialists, among them Faure (1952) and Tokioka (1955, 1961). However, Tokioka (1974) has changed his opinion, stating, "...*tenuis* and *friderici* are very probably ecological forms of the single species *Sagitta tenuis*; *tenuis* is the typical form of the species developed limitedly in embayments in lower latitudes and of higher water temperature (and probably salinity), while *friderici* is the form developed in the open neritic waters of lower temperature (and probably salinity, too). The distributional areas of these two forms are adjoining each other." The fact that McLelland (1980) differentiated both species in his samples, the two occupying basically the same habitat in the northeastern Gulf of Mexico, supports the validity of *S. friderici* and demonstrates the need for further study of populations of the two forms.

Sagitta helenae Ritter-Záhony, 1910

Figures 23, 24

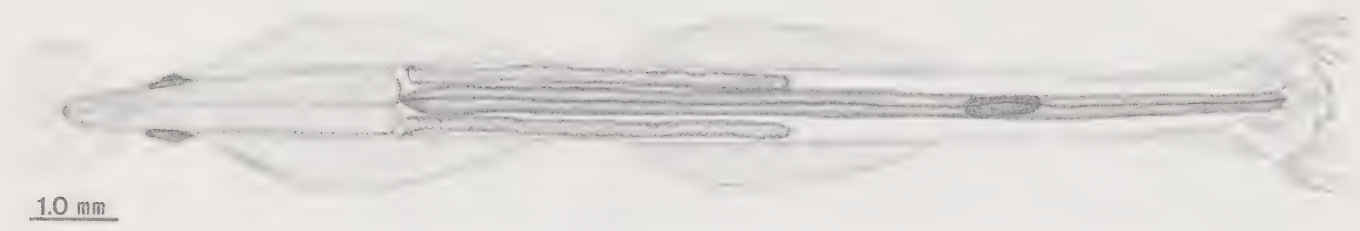

Figure 23.—*Sagitta helenae*, dorsal view.

Sagitta helenae Ritter-Záhony, 1910.

Sagitta helenae, Ritter-Záhony, 1911a, b; Pierce, 1951; Tokioka, 1955; Bumpus and Pierce, 1955; Owre, 1960; Pierce and Wass, 1962; Alvariño, 1969.

Description. Length, to 15 mm; T%, 23-30; hooks, 6-8; anterior teeth, 8-18; posterior teeth, 7-14. The number and arrangement of the anterior teeth distinguish the species from immature *Sagitta hispida*, a generally similar form. The bases of the teeth overlap, and, as Pierce (1951) observed, in most preserved specimens they extend away from the head, resembling a miniature curved fan. Also, as pointed out here in the description of *S. hispida*, the form of the eye pigment in *S. helenae* differs in being concentrated in a smoothly ovoid area (Tokioka 1955). The conspicuous collarette extends approximately halfway between the neck and the anterior end of the ventral ganglion. Ritter-Záhony (1911a) described the corona ciliata as elongated and slightly sinuous, reaching from the region of the cerebral ganglia onto the trunk for a distance about twice the length of the head. Both anterior and posterior fins are supported by rays. The anterior pair lies just posterior to the ventral ganglion; the greater length of the posterior pair is divided approximately equally by the transverse septum.

Figure 24.—*Sagitta helenae*, ventral view of head.

There are no intestinal diverticula. Ripe ovaries may extend to the level of the ventral ganglion according to Alvariño (1969); others have found them to be considerably shorter (Pierce 1951; Tokioka 1955; present observations). Ovoid, mature seminal vesicles, expanded at the anterior end, occupy most of the space between lateral and caudal fins and are separated from the latter by about one-seventh of their length (Tokioka 1955).

Distribution. This neritic species appears to be restricted to the North Atlantic. It has been recorded from Delaware to the vicinity of Key West, Fla., on the eastern seaboard of the United States. Pierce and Wass (1962) found it to be numerous between the approximate locations of Cape Hatteras, N.C., and Palm Beach, Fla., and termed it a typical continental shelf species. It is also common off the west coast of Florida south of the Cedar Key area (Pierce 1951), in other parts of the Gulf of Mexico (Pierce 1954, 1962), and has been reported from the Cariaco Trench, Venezuela (Legaré and Zoppi 1961), and from Brazil (Alvariño 1968). A few specimens collected at stations within the Lesser Antillean Arc in the Caribbean were regarded by Michel et al. (1976) as indicators of strong coastal influence within the eastern Caribbean in the fall, following the wet season in northeastern South America.

Sagitta hexaptera d'Orbigny, 1843

Figure 25

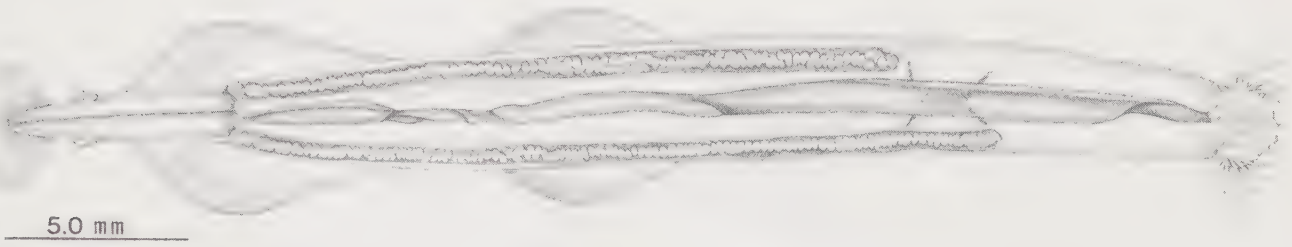

Figure 25.—*Sagitta hexaptera*, dorsal view.

Sagitta hexaptera d'Orbigny, 1843.
Sagitta hexaptera, Ritter-Záhony, 1911b; Owre, 1960; Pierce and Wass, 1962; Alvariño, 1969; Stepien, 1980.

Description. Length, to 40 mm; T%, 17-20; hooks, 7-10; anterior teeth, 2-4; posterior teeth, 2-6. The few, long, sharp, anterior teeth, which usually project forward in preserved specimens, are a distinctive feature. There is no collarette. The pyriform corona ciliata lies entirely on the head just posterior to the cerebral ganglia. Inner regions of both the short, rounded, anterior fins and the longer, deltoid, posterior fins are rayless.

There are no intestinal diverticula. Ripe ovaries may extend to the level of the ventral ganglion. Small, rounded, seminal vesicles develop between lateral and caudal fins, slightly closer to the latter.

Distribution. This easily recognized species occurs around the world in temperate and tropical oceanic areas. Owre (1960) reported that it was most numerous at approximately 100 m on the western side of the Florida Current off Miami and 300 m on the eastern side. In the Caribbean region, *S. hexaptera* occurs in both Tropical Surface Water and Subtropical Underwater and is collected primarily from the latter (Michel et al. 1976).

Sagitta hispida Conant, 1895

Figure 26

Sagitta hispida Conant, 1895.
Sagitta hispida, Pierce, 1951; Bumpus and Pierce, 1955; Tokioka, 1955; Suárez-Caabro, 1955; Legaré and Zoppi, 1961; Almeida Prado, 1968; Alvariño, 1969.

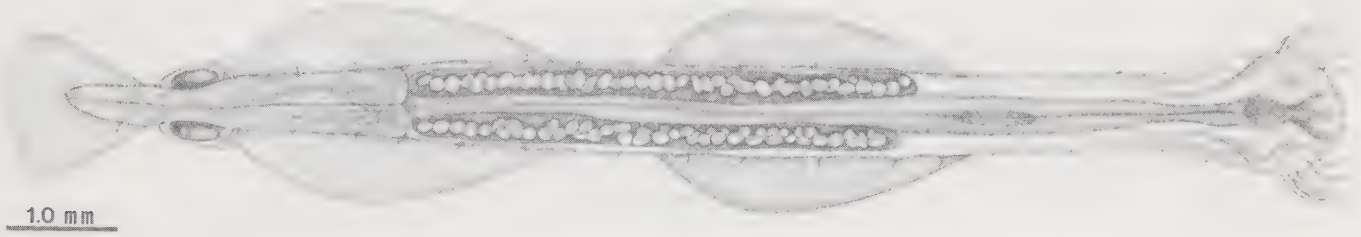

Figure 26.—*Sagitta hispida*, dorsal view.

Description. Length, to 14 mm; T%, 26-29; hooks, 6-9; anterior teeth, 4-10; posterior teeth, 8-15. Measurements and counts of hooks and teeth have been published by Conant (1895), Pierce (1951), Suárez-Caabro (1955), Tokioka (1955), and Legaré and Zoppi (1961). It should be noted that the measurements of total length in the latter two publications include the caudal fin.

Pierce (1951) and Tokioka (1955) redescribed this stout, large-headed species, which is characterized by a thick collarette in the neck region and an elongate corona ciliata, extending from a point anterior to the eyes posteriorly onto the trunk, ending short of the ventral ganglion. The numerous sensory hairs, which are arranged in species-specific hair-fan patterns (Feigenbaum 1978), give the body the hispid appearance from which the name was derived. Both pairs of lateral fins are supported throughout by rays. The anterior fins extend to the ventral ganglion. The posterior fins, broadest behind the transverse septum, reach the seminal vesicles, which are widely separated from the caudal fin.

Tokioka (1955) illustrated differences in the eye pigment of *Sagitta helenae* and *S. hispida*, species which may occur in the same area and are similar in general appearance until sexual maturity is attained. These differences have consistently served as convenient characteristics to separate immature forms. In *S. helenae*, the pigment is concentrated in a uniformly black, smoothly ovoid spot. In *S. hispida*, this area is slightly concave laterad, and the pigment appears concentrated in a band along the concave margin. At approximately the middle of the band, a shorter band extends mediad at right angles to it. The black pigment is thus concentrated in a T-shaped area, and the remainder of the ovoid spot is less densely pigmented.

Intestinal diverticula are present. Fully formed ovaries virtually fill the trunk coelom. The seminal vesicles are broadly expanded at the anterior end and, in mature specimens, also have a second, more posterior bulge. For extensive information about the reproduction of this species, as well as other aspects of its biology, the reader is referred to the works of Reeve (1964a, b, 1966, 1970a, b), Reeve and Cosper (1975), Reeve and Lester (1974), and Reeve and Walter (1972a, b).

Distribution. Since its description by Conant, from specimens collected off Beaufort, N.C., *S. hispida* has been erroneously reported from many parts of the world. It is an Atlantic species, abundant and widely distributed in temperate and tropical coastal waters of islands as well as continents (Pierce 1951; Tokioka 1955; Owre 1960; Legaré and Zoppi 1961; Almeida Prado 1968; Owre 1972b; Owre and Foyo 1972; Michel et al. 1976; McLelland 1978). Alvariño (1965, 1969) illustrated its distribution as trans-Atlantic, with latitudinal extremes of approximately 34°N and 30°S. As Reeve (1970a) stated, "There appears to be considerable doubt as to its occurrence, at least in any numbers, in mid-Atlantic waters...." A plot of records listed in Alvariño's 1969 work shows that the collections were made near land, with a few exceptions in areas off northeastern South America and east of the Lesser Antilles where outflow from the Amazon and Orinoco Rivers strongly influences the distribution of planktonic organisms. Specimens could also be transported from northwestern Africa to these areas by the North Equatorial Current. Although *S. hispida* has been collected occasionally in the Florida Straits 10 mi east of Miami and even 40 mi east, Owre (1960) concluded that its presence indicated mixing of neritic and oceanic waters. Those occurring at the former location may have originated in coastal waters of the Gulf of Mexico or Cuba. The site 40 mi east of Miami is near the shallow waters of the western Bahamian island chain, where *S. hispida* is extremely abundant. One specimen reported from 685 m has been considered a contaminant since all of our knowledge of its vertical distribution shows it to be an epiplanktonic species. However, Stepien (1978), who collected it at 681 and 685 m at a site farther west in the Straits, regarded it as an indicator of entrained surface waters.

Sagitta lyra Krohn, 1853

Figure 27

Sagitta lyra Krohn, 1853.

Sagitta lyra, Ritter-Záhony, 1911a, b; Germain and Joubin, 1916; Moore, 1949; David, 1955; Owre, 1960; Alvariño, 1969.

Description. Length, to 42 mm; T%, 14-28, usually 14-18; hooks, 3-11; anterior teeth, 2-8; posterior teeth, 2-12. Data on some large Caribbean specimens collected at 1,000 m (Michel et al. 1976: Cruise P 6911, Station 7) are:

Length (mm)	*T%*	*H*	*Ta*	*Tp*
30	28	4-4	3-3	4-4
25	16	4-4	5-5	3-3
25	16	4-4	7-7	3-3
24	17	6-6	4-5	5-5

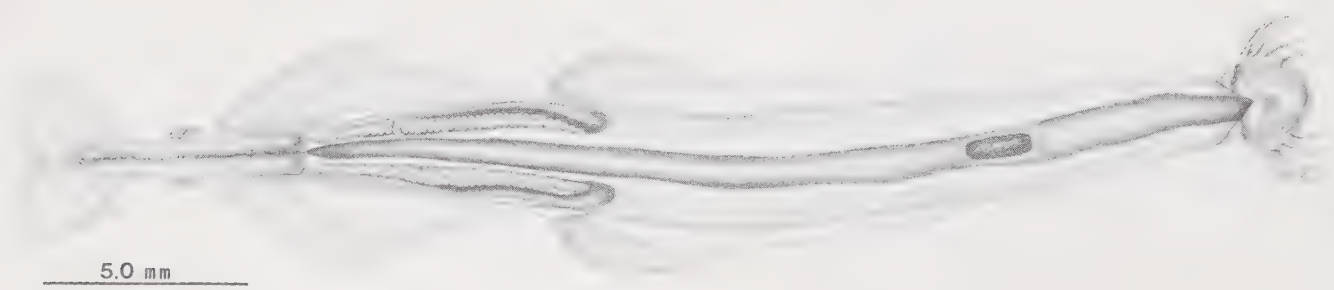

Figure 27.—*Sagitta lyra*, dorsal view. The indentation in the posterior margin of the caudal fin is an artifact.

Sagitta lyra resembles *S. enflata* and *S. hexaptera* in its relatively broad, weakly muscled body. It is distinguished by a bridge of rayless, epidermal tissue which connects the anterior and posterior lateral fins. Both pairs of fins have rays in the outer portion, and in the anterior pair, these are found only in the posterior part. The anterior fins extend to, or nearly to, the ventral ganglion.

The species lacks a collarette, according to Ritter-Záhony (1911a, b). However, a small collarette is present in Caribbean specimens, and this feature has also been noted in specimens from the eastern North Atlantic and the Mediterranean (Casanova 1977). Alvariño (1962), in her original description of *S. scrippsae*, pointed out that it has a collarette, whereas *S. lyra* does not. Casanova (1977) obtained specimens of *S. scrippsae* to compare with *S. lyra*, and he concluded that the former is a subspecies of the latter.

Mature animals have seldom been found in our collections. According to Ritter-Záhony (1911a), the ovaries may extend as far as the middle of the anterior lateral fins; Alvariño (1969) showed them reaching the anterior third of these fins. There is a marked constriction of the body just posterior to the seminal receptacles, at the level of the transverse septum. The small, rounded, seminal vesicles are situated midway between the posterior lateral and caudal fins.

Distribution. *Sagitta lyra* is a mesopelagic oceanic species which is cosmopolitan in warm and temperate latitudes. It has been collected in Tropical Surface Water, where it is an indicator of upwelling, Subtropical Underwater, Subantarctic Intermediate Water, and North Atlantic Deep Water, but the majority of the populations lives in the two intermediate water masses (Michel et al. 1976).

Sagitta macrocephala Fowler, 1905

Figures 28, 29

Figure 28.—*Sagitta macrocephala*, dorsal view.

Sagitta macrocephala Fowler, 1905.

Sagitta macrocephala, Ritter-Záhony, 1911a, b; Owre, 1960; Alvariño, 1969; Stepien, 1980.

Description. Length, to 22 mm; T%, 29-36; hooks, 10-12; anterior teeth, 6-10; posterior teeth, 17-38. The large, rectangular head and numerous brown hooks and teeth are distinctive features. There is no collarette. The corona ciliata has not been described; Ritter-Záhony (1911a) suggested that it is destroyed during the long period between the capture of this deep-living species and its preservation. The eyes lack pigment. The short anterior fins, located posterior to the ventral ganglion, are fully rayed. The much longer and broader posterior fins also contain rays except for an inner area which extends to and includes the anterior portions of these fins.

There are no intestinal diverticula. Ripe ovaries may extend to the level of the ventral ganglion, according to Alvariño (1969). Ovoid seminal vesicles are not in contact with either lateral or caudal fins but develop closer to the former than to the latter. Mature specimens have rarely been collected in the area considered here.

Distribution. This species, generally described as cosmopolitan and mesopelagic, has been reported from the Antarctic and the Subantarctic, and from the Atlantic, Pacific, and Indian Oceans. Owre (1960) found only two individuals in collections from the

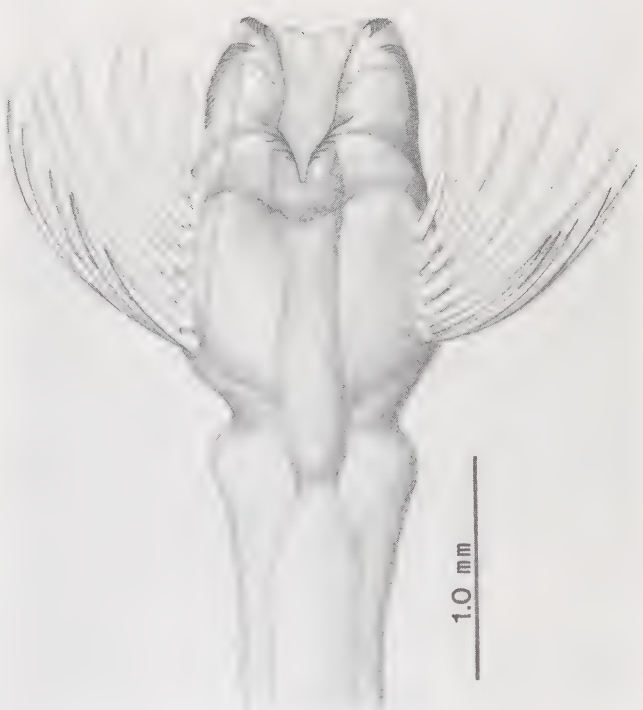

Figure 29.—*Sagitta macrocephala*, ventral view of head.

Florida Straits but it was common in Stepien's (1980) samples. More extensive sampling in the Caribbean region showed that it is widely distributed in both mesopelagic and bathypelagic realms and restricted to Subantarctic Intermediate and North Atlantic Deep Waters (Michel et al. 1976).

Sagitta megalophthalma Dallot and Ducret, 1969

Figures 30, 31, 32, 33

Figure 30.—*Sagitta megalophthalma*, dorsal view.

Figure 31.—*Sagitta megalophthalma*, immature, dorsal view.

Sagitta megalophthalma Dallot and Ducret, 1969.

Sagitta megalophthalma Michel, Foyo, and Haagensen, 1976; Stepien, 1980.

Description. Length, to 21 mm or more; T%, in the largest individuals, approximately 23.5; hooks, 7-8; anterior teeth, as many as 10; posterior teeth, as many as 18. Collarette is well developed, situated in the neck region and on the anterior trunk. Corona ciliata is narrow, sinuous, and elongated, beginning just anterior to the level of the eyes and extending to a point about halfway between the cephalic septum and the ventral ganglion. Eyes (Fig. 33) are diagnostic because of the large pigmented area, the general configuration of which is rectangular, and the divergence of the longitudinal axes of these areas to form an angle of approximately 45°, opening anteriorly. Very fine rays are found throughout the pairs of lateral fins. The anterior fins originate posterior to the ventral ganglion, from which they are separated by a distance equal to approximately half its length, and they are well separated from the slightly longer posterior fins.

There are no intestinal diverticula. A portion of the intestine, about two-thirds of the total length of the digestive tube, is characterized by conspicuous vacuolar cells. Dallot and Ducret (1969) did not believe that they had observed completely mature ovaries, nor has the writer. Mature ovaries containing rounded ova probably extend at least to the region of the anterior end of the posterior lateral fins. The ovoid seminal vesicles develop well posterior to the lateral fins and are separated by a lesser distance from the base of the caudal fin.

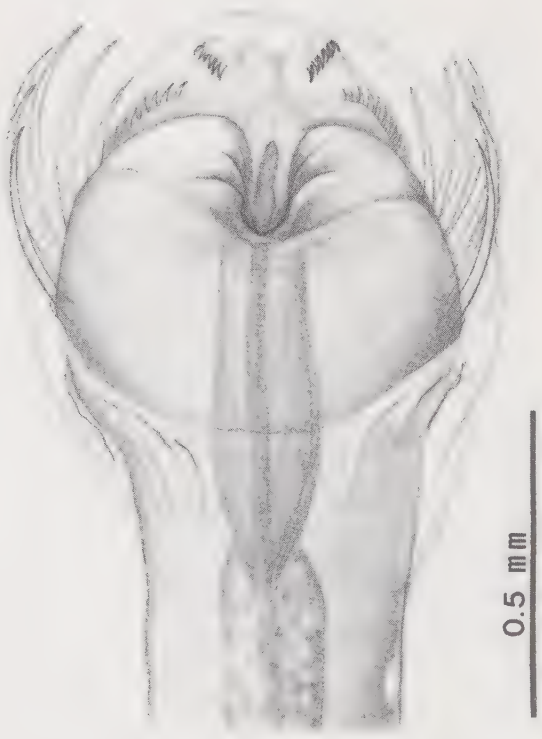

Figure 32.—*Sagitta megalophthalma*, ventral view of head.

Figure 33.—*Sagitta megalophthalma*, left (a) and right (b) eyes.

Distribution. *Sagitta megalophthalma* was described from specimens collected between 100 and 700 m in the western Mediterranean; additional material from the Tyrrhenian Sea and the Gulf of Guinea contributed to knowledge of the species (Dallot and Ducret 1969). Michel et al. (1976) reported a few individuals in samples from the Caribbean Sea. Specimens collected by Mattlin (1974), most from the upper 50 m, in the Cariaco Trench were identified by the writer as *S. megalophthalma*. Stepien (1980) and Cheney (1982, footnote 4) found a few in the Florida Straits and the northwest North Atlantic, respectively. This distinctive species remains so poorly known that it is possible only to speculate on its distribution. In the North Atlantic, it appears to be an upper mesopelagic species which may be entrained to shallower water. Michel et al. (1976) suggested that it may be an indicator of water movement from the North Atlantic into the Caribbean Sea.

[4]J. Cheney, Postdoctoral appointment, Institute of Oceanography, Dalhousie University, Halifax, Nova Scotia, Canada, pers. commun. May 1981.

Sagitta Minima Grassi, 1881

Figure 34

Sagitta Minima Grassi, 1881.
Sagitta minima, Ritter-Záhony, 1911a; Pierce, 1953, 1962; Owre, 1960; Alvariño, 1969.

Description. Length, to 9 mm; T%, 17-24; hooks, 7-9; anterior teeth, 2-5; posterior teeth, 6-14. There is no collarette. Corona ciliata is an elongate oval in shape and is located on the anterior trunk (Ritter-Záhony 1911a). The anterior and posterior pairs of fins contain rays in their outer portions but the fins are so fragile that these areas may be lost. The anterior pair is particularly hard to see. The posterior fins lie mainly on the trunk. The body of this small species may be flaccid owing to the effects of capture and preservation.

Intestinal diverticula are present, and, posterior to them, the digestive tube is the vacuolar type described by Dallot (1970). The short, club-shaped, mature ovaries hardly extend past the middle of the posterior fins. The elongated seminal vesicles develop adjacent to the caudal fin, lying far posterior to the lateral fins.

Figure 34.—*Sagitta minima*, dorsal view.

Distribution. *Sagitta minima* is a cosmopolitan, epipelagic species, which, in the southwestern North Atlantic and the Florida Straits, is found in greatest numbers in oceanic water at the edge of the continental shelf (Owre 1960; Pierce and Wass 1962). It has also been reported from the Caribbean and adjacent areas by Prado (1961), Mattlin (1974), and Michel et al. (1976).

Sagitta planctonis Steinhaus, 1896

Steinhaus (1896) described *S. planctonis* from specimens collected in shallow tows in the Atlantic South Equatorial Current. A similar species, *S. zetesios*, was described from deep water in the Bay of Biscay by Fowler (1905). *Sagitta zetesios* was synonymized with *S. planctonis* by Ritter-Záhony (1911a), and other workers agreed until specimens subsequently collected revived the problem of distinguishing the two forms. David (1956) concluded that *S. zetesios* is a valid species. Aurich (1971) and Pierrot-Bults (1969, 1970, 1975) have worked extensively with North Atlantic specimens, reporting the presence of intermediates in collections containing both species and analyzing latitudinal and vertical distribution. After making factor and discriminant analyses, Pierrot-Bults (1975) decided that this is a polytypic species composed of the formae *planctonis* and *zetesios*. The specimens that Moore (1949) reported from the shallow waters in the Bermuda area as *S. planktonis*, and identification confirmed by F. S. Russell and J. W. S. Marr, were probably strays of *S. planctonis* forma *planctonis*, although both formae and the intermediates occur there. Pierrot-Bult's (1975) data for the latitude of Bermuda indicate that the intermediates and forma *zetesios* do not occur in the upper 300 m. Both formae have been collected in the regions considered herein, *planctonis* being rare and *zetesios* more numerous.

Sagitta planctonis forma *planctonis* Steinhaus, 1896

Figure 35

Figure 35.—*Sagitta planctonis* forma *planctonis*, dorsal view.

Sagitta planctonis Steinhaus, 1896.
Sagitta planctonis, Fowler, 1905, 1906; Tokioka, 1940; Thomson, 1947; David, 1956; Colman, 1959; Owre, 1960.
Sagitta planktonis, Michael, 1911; Moore, 1949.
Sagitta planctonis forma *planctonis*, Pierrot-Bults, 1975.

Description. Length, to 37 mm; T%, 19-23; hooks, 6-11, usually 8-11; anterior teeth, 5-9, usually 6-8; posterior teeth as many as 14, usually 10-12. Collarette is prominent, extending at least to the level of the anterior fins and, according to David (1956), even to the tail in fully grown specimens. Corona ciliata, as described by David (1956) from the illustration by Tokioka (1940), begins on the posterior part of the head and extends to a point about halfway between head and ventral ganglion. Anterior fins, which may extend to the level of the middle of the ventral ganglion, lack rays in inner and anterior portions. Triangular posterior fins, with the rays limited to the outer portions, are broadest at approximately the level of the transverse septum.

Intestinal diverticula are present. Fully mature ovaries fill the trunk coelom. The anteriorly rounded, elongate seminal vesicles are located next to the posterior fins and are separated from the caudal fin.

Distribution. David (1956) attempted to clarify the anomalous distribution of this species, showing that there are three species previously recognized as one: *S. planctonis* is "epiplanktonic" in warm waters, *S. zetesios* lives in deep oceans, except for the Antarctic, and *S. marri* David 1956, is probably endemic to the Antarctic. Moore's (1949) perplexity at the shallow habitat of *S. planctonis* off Bermuda was thus explained by David, who recorded its distribution as "Bermuda, S.E. Africa, (Aghulas current area), Tasman Sea, off N.E. New Zealand, and parts of N. Atlantic. A surface living form breeding at a moderate depth (1000-750 m)." Pierrot-Bults (1975) has since shown that *S. planctonis* forma *planctonis* occurs over a range of approximately 100-1,000 m between lat. 45°N and 40°+S in the Atlantic Ocean.

Colman (1959) collected two specimens in tows made with open nets, from 900 and 1,000 m, in the area between St. Paul's Rocks and the west coast of Africa. Owre (1960) found only two specimens in samples from the Florida Straits, at approximately 150 and 730 m, a record listed by Alvariño (1965) as *S. zetesios*, with a question mark. One specimen was found by Michel et al. (1976) in a Caribbean sample from 739 m, in Subantarctic Intermediate Water. Its occurrence in the Caribbean and the Florida Straits probably indicates the presence of North Atlantic Central Water as well as SAIW.

Sagitta planctonis forma *zetesios* Fowler, 1905

Figures 3, 36

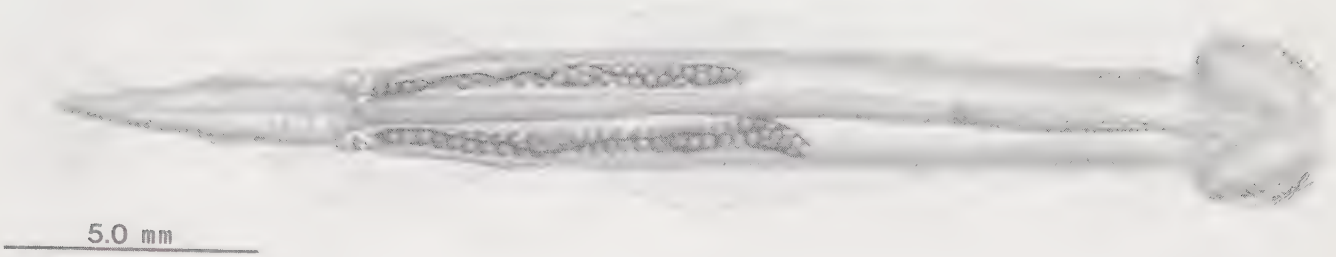

Figure 36.—*Sagitta planctonis* forma *zetesios*, dorsal view.

Sagitta zetesios Fowler, 1905.
Sagitta zetesios, Fowler, 1906; Michael, 1911.
Sagitta planctonis, (non Steinhaus), Ritter-Záhony, 1911a (partim); Germain and Joubin, 1916; Tokioka, 1939; Fraser, 1952.
Sagitta zetesios, David, 1956; Colman, 1959; Alvariño, 1967.
Sagitta planctonis forma *zetesios*, Pierrot-Bults, 1975.

Description. Length, to 43 mm; T%, 20-26; hooks, 8-11; anterior teeth, 6-12, usually 8-10; posterior teeth, 10-22. Collarette is prominent, extending at least to the level of the anterior fins and, according to David (1956), even onto the tail in large specimens. Corona ciliata is elongated, beginning on the neck and extending toward the ventral ganglion. Anterior fins reach the level of the posterior end of the ventral ganglion and have few or no rays in the anterior portion. Posterior fins are triangular, with the apex approximately coinciding with the transverse septum. Refer to the description of forma *planctonis* for additional information about the fins.

Intestinal diverticula are present. Mature ovaries may extend to the ventral ganglion. As in forma *planctonis*, the elongate, rounded, seminal vesicles are situated next to the posterior fins and are well separated from the caudal fin.

Immature specimens of 20 mm and less lack the extensive collarette of larger forms; it is confined to the region of the neck. The presence of diverticula and an intestine of Dallot's (1970) type 2, with many vacuolar cells, aid in identification. Although the posterior teeth in mature specimens regularly number more than 14, smaller individuals have fewer teeth. Data on 10 immature specimens are given in Table 5.

Distribution. David (1956) described this as a deep-living form found in most oceans but absent from the Antarctic. In the Atlantic, Colman (1959) collected it from approximately 750 to 1,300 m, at stations extending from the waters off S.W. Greenland to Brazil. Aurich (1971) and Pierrot-Bults (1975) have shown that the distribution of forma *zetesios* extends into the upper 150 m in North Atlantic cold-temperate waters, and that it gradually deepens in the lower latitudes. In the areas considered here, between approximately lat. 35° and 10°N, it has an overall range of about 400 to 1,250 m, according to Pierrot-Bults (1975). Although forma *zetesios* was never numerous in Caribbean samples, Michel et al. (1976) found it widely distributed both horizontally ("...caught in nearly every part of the Caribbean...") and vertically (from 38 m in the Windward Passage to 3,000 m in the Colombian Basin of the central Caribbean). Stepien (1978) collected one specimen in the Florida Straits at 687 m. Both formae of *S. planctonis* probably indicate intrusion of North Atlantic water in the Caribbean and adjacent areas. If reproducing populations existed there, they would probably have been sampled by now.

Table 5.—Measurements and counts of teeth of immature *Sagitta planctonis* forma *zetesios*.

Length (mm)	T%	H	Ta	Tp	Station[1] and depth
9.5	26.0	9-9	7-7	13-?	P6911, Stn. 4, 423 m
9.5	26.0	10-10	6-6	10-12	P6911, Stn. 4, 423 m
10.0	25.0	?	8-8	?-16	P6805, Stn. 4, 500 m
12.0	26.0	9-10	5-6	?	P6911, Stn. 4, 423 m
12.2	24.5	8-8	8-?	13-11	P6805, Stn. 4, 500 m
15.0	25.0	9-9	7-?	17-17	P6805, Stn. 4, 500 m
16.5	24.0	9-9	8-8	15-16	P6911, Stn. 7, 779 m
17.0	23.5	8-9	8-9	15-15	P6805, Stn. 10, 477 m
19.3	24.0	9-9	9-10	15-?	P6911, Stn. 3, 494 m
20.0	23.5	?	?	?	P6911, Stn. 3, 494 m

[1]P6805, Stn. 4, 19°02′N, 80°20′W; P6805, Stn. 10, 14°32′N, 68°11′W; P6911, Stn. 3, 15°00′N, 62°00′W; P6911, Stn. 4, 14°15′N, 61°40′W; P6911, Stn. 7, 15°01′N, 64°32′W (Michel et al. 1976).

Sagitta serratodentata Krohn, 1853

Figures 37, 38

Sagitta serrato-dentata Krohn, 1853.
Sagitta serratodentata, Ritter-Záhony, 1911a, b; Owre 1960; Pierce and Wass 1962; Grant, 1967; Alvariño, 1969; Stepien, 1980.

Description. Length, to 15 mm; T%, 20-28; hooks, 6-7; anterior teeth, to 11; posterior teeth, to 20. The inner margins of the hooks are serrated, usually not as coarsely as illustrated in Figure 38. A short collarette can be observed in the neck region. The elongate,

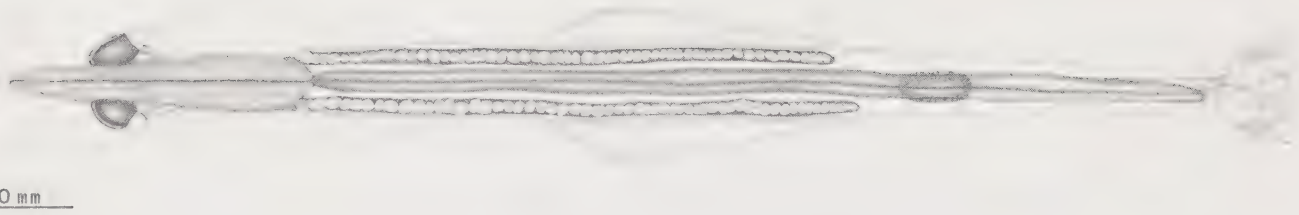

Figure 37.—*Sagitta serratodentata*, dorsal view.

sinuous corona ciliata extends from an area just posterior to the cerebral ganglia onto the trunk for a distance at least twice the length of the head. Both pairs of the long lateral fins have a small inner rayless area. The anterior pair originates just posterior to the level of the ventral ganglion.

There are no intestinal diverticula. Mature ovaries may reach the level of the anterior end of the anterior fins. Seminal vesicles, even before maturity, have a distinctive shape, in that a membranous supporting structure extends from the lateral fins to the anterior portion of each vesicle, producing a deltoid appearance. Anteriorly, mature vesicles are characterized by a pair of clawlike projections.

Distribution. *Sagitta serratodentata* is a common, epipelagic, oceanic species in subtropical and tropical waters of the North Atlantic. It has also been reported from the Pacific and Indian Oceans and the Mediterranean Sea. Grant (1967) analyzed its distribution compared with the similar *S. tasmanica* in the North Atlantic. Owre (1960) observed that, in the Florida Straits off Miami, it was second to *S. enflata* in abundance on the western side but the most abundant species at the eastern station. In the Caribbean and the Gulf of Mexico, it is found in both Tropical Surface Water and Subtropical Underwater and is most numerous in the former (Michel et al. 1976).

Figure 38.— *Sagitta serratodentata*, ventral view of head.

Sagitta tenuis Conant, 1896

Figure 39

Sagitta tenuis Conant, 1896.

Sagitta tenuis, Pierce, 1951; Faure, 1952; Tokioka, 1955; Bumpus and Pierce, 1955; Legaré and Zoppi, 1961; Alvariño, 1969; Owre and Foyo, 1972; McLelland, 1980; Stepien, 1980.

Description. Length, to 8.2 mm; T%, 25-29; hooks, 7-9; anterior teeth, 4-7; posterior teeth, 7-17. A thin collarette is present in the neck region. Corona ciliata is about 2.5 times the length of the head (Tokioka 1955). Eye pigment forms a spot almost exactly

Figure 39.—*Sagitta tenuis*, dorsal view. The indentation in the posterior margin of the caudal fin is an artifact.

square in shape, in contrast to the oval form illustrated by Tokioka (1955). Lateral fins are similar to those of *S. friderici*, completely set with rays. However, the anterior fins may not extend as far anteriorly as the ventral ganglion.

There are no intestinal diverticula. Ripe ovaries contain large ova arranged in a single row. As many as 15 ova have been counted in each ovary of a mature specimen. The ovaries usually do not extend beyond the anterior edge of the posterior fins although they may swell slightly beyond this level. The thin, elongate seminal vesicles lie between the posterior and caudal fins, reaching them both at maturity, and are bulbous in the anterior portion.

Distribution. The broad latitudinal range of this eurythermal, euryhaline, neritic species was discussed by Owre and Foyo (1972), who noted that it had been reported from Delaware to Brazil in waters of 3.5°-27.5°C and 10.9-39.7‰. McLelland (1978) made an interesting report of its cooccurrence with *S. friderici* in the northeastern Gulf of Mexico. It was third in abundance after *S. friderici* and *S. enflata* and was most numerous in salinities of 30.0-35.9‰ and temperatures of 26.0°-30.3°C. Although common in other parts of the Gulf of Mexico, including waters off the west coast of Florida, it has rarely been reported from the east coast of Florida south of Salerno, in the vicinity of Cape Canaveral. Recently, Barbara K. Sullivan, while working at Harbor Branch Foundation, Inc., Ft. Pierce, Fla., collected a few specimens in the Indian River lagoon and also in coastal Atlantic water east of the Ft. Pierce Inlet, areas where *S. hispida* is the dominant form. North of Cape Canaveral, it becomes a numerous component of the nearshore plankton as far as the latitude of Delaware (Grant 1963a). The presence of *S. tenuis* in a sample from 691 m in the Florida Straits off Miami was regarded by Stepien (1980) as an indication that coastal water contributes to the countercurrent beneath the Florida Current.

Pterosagitta draco (Krohn, 1853)

Figure 5

Sagitta draco Krohn, 1853.
Pterosagitta mediterranea, A. Costa, 1869.
Spadella draco, Langerhans, 1880; Fowler, 1906; Ritter-Záhony, 1910.
Pterosagitta draco, Ritter-Záhony, 1911a.
Pterosagitta besnardi, Vannucci and Hosoé, 1952.
Pterosagitta draco, Owre, 1960; Tokioka, 1965a; Alvariño, 1965, 1969.

Description. Length, to 10.5 mm; T%, 38-46; hooks, 8-10; anterior teeth, 5-9; posterior teeth, 8-18. The prominent collarette, which extends the length of the body, is most noticable on the trunk. In perfectly preserved specimens, a pair of long, V-shaped "hair-fans" can be seen on either side of the anterior third of the collarette. These are not the only epidermal structures on the collarette, but they are exceptionally long and, in the literature, have been called "wings." Bieri (1966) observed and experimented with these tufts in a living specimen, and he postulated that they serve as detectors of water motion. The collarette is often nearly or entirely destroyed during collection by net. The oval, elongate corona ciliata is located on the anterior trunk, beginning in the region of the neck (Ritter-Záhony, 1911b). One pair of fully rayed, rounded lateral fins originates at the transverse septum and extends to the seminal vesicles.

There are no intestinal diverticula. When mature, the ovaries may fill the trunk coelom to the septum between head and trunk, and the seminal vesicles extend between the lateral and caudal fins.

Distribution. This is an epipelagic oceanic species, cosmopolitan in temperate and tropical waters, and often reported from the western North Atlantic and adjacent areas (Alvariño 1969). In the Caribbean Sea and the Gulf of Mexico, it is among the most numerous forms and is maximally abundant in the upper 100 m (Michel et al. 1976).

Krohnitta pacifica (Aida, 1897)

Figure 40

Krohnia pacifica Aida, 1897.
Eukrohnia pacifica, Michael, 1911.
Krohnitta pacifica, Tokioka, 1939, 1940, 1942; Thompson, 1947; Pierce, 1951, 1953, 1954, 1958, 1962; Suárez-Caabro, 1955; Owre, 1960; Legaré and Zoppi, 1961; Alvariño, 1963, 1965, 1967.

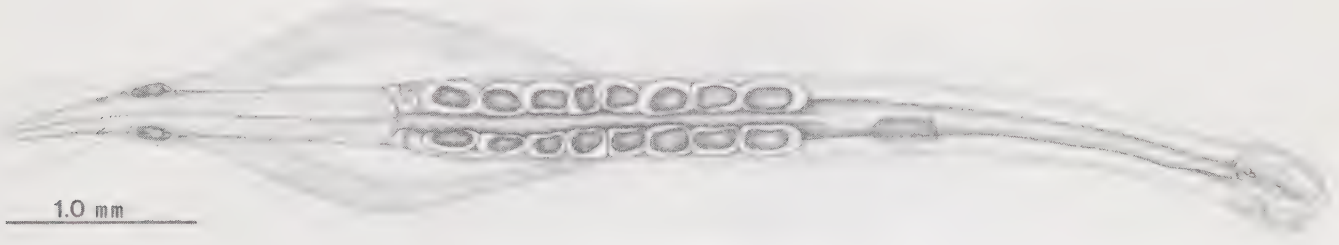

Figure 40.—*Krohnitta pacifica*, dorsal view.

Krohnitta subtilis (partim), Ritter-Záhony, 1910, 1911a.
Krohnitta mutabbii, Alvariño, 1969.
Krohnitta pacifica, Owre, 1973.

Description. Length, to approximately 7.5 mm; T%, 26-31; hooks, 7-10; teeth, 11-16. The corona ciliata originates in the mid-dorsal region just posterior to the eyes, extends to its greatest width on the neck, and then tapers to its termination on the anterior part of the trunk (Ritter-Záhony 1911a; Suárez-Caabro 1955). The lateral fins usually contain rays in the outer portion, from the anterior to the posterior end, and have an inner rayless area of variable extent.

There are no intestinal diverticula. Mature ovaries extend well beyond the anterior extremity of the lateral fins and may reach the vicinity of the ventral ganglion. The oval seminal vesicles are in contact with both caudal and lateral fins.

Records indicate that Indo-Pacific specimens having hook and tooth counts similar to Atlantic forms may be longer, with a proportionately larger caudal segment (e.g., 6-9 mm, 29-36 T%, Thompson 1947; 4.2-7.2 mm, 28.1-37.5 T%, Sund 1959; 6-8 mm, 27-34 T%, Alvariño 1967). Alvariño (1969) proposed the new species *K. mutabbii* for the Atlantic forms; Owre (1973) put this name in synonymy on the grounds that sufficient differences to erect a new species had not been demonstrated.

Distribution. Originally believed to be an Indo-Pacific species, *K. pacifica* has been reported many times from the western North Atlantic and the Gulf and Caribbean areas (e.g., Pierce 1951, 1953, 1954, 1958, 1962; Pierce and Wass 1962; Suárez-Caabro 1955; Suárez-Caabro and Madruga 1960; Owre 1960; Legaré and Zoppi 1961; Michel et al. 1976; McLelland 1978). Michel et al. (1976) reported that it is found primarily in the upper 200 m, in Tropical Surface Water and Subtropical Underwater.

Krohnitta subtilis (Grassi, 1881)

Figures 4, 41

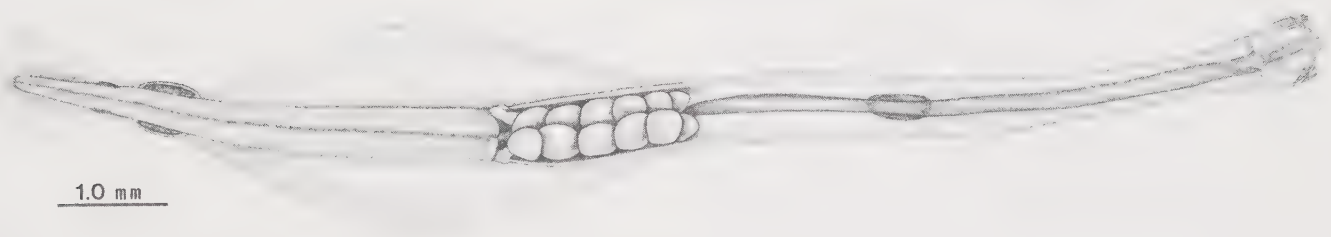

Figure 41.—*Krohnitta subtilis*, dorsal view.

Sagitta Suptilis (sic) Grassi, 1881.
Spadella Subtilis, Grassi, 1883.
Krohnia subtilis, Fowler, 1905, 1906.
Eukrohnia subtilis, Michael, 1911.
Krohnitta subtilis (partim), Ritter-Záhony, 1911a.
Krohnitta subtilis, Suárez-Caabro, 1955; Owre, 1960; Alvariño, 1969.

Description. Length, to approximately 16 mm; T%, 30-40; hooks, 6-9; teeth, 10-13. Corona ciliata is approximately deltoid, about as long as the head, and lies on an area between the anterior trunk and a point posterior to the eyes (Ritter-Záhony 1911a, b; Suárez-Caabro 1955). The broad lateral fins contain rays in their outer portions, with about one-third of their extent situated on the trunk and the remainder on the caudal segment.

There are no intestinal diverticula. Mature ovaries rarely extend beyond the anterior edge of the lateral fins. Oval mature seminal vesicles are in contact with both caudal and lateral fins.

Distribution. *Krohnitta subtilis* is primarily mesoplanktonic in the Caribbean area but has been collected from lower Tropical Surface Water through Subtropical Underwater (Michel et al. 1976; Tables 2, 3). It has been reported from the Florida Straits (Owre 1960; Stepien 1980), Cuban waters (Suárez-Caabro 1955), the Gulf of Mexico (Pierce 1962; McLelland 1978), the north Atlantic off Trinidad (Vannucci and Hosoé 1952), and from the Amazon area (Alvariño 1968).

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